UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

SEISMOLOGY IN INDIA: COLONIAL GEOLOGISTS AND THE RAJ, 1880-1910

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF ARTS IN HISTORY OF SCIENCE, TECHNOLOGY AND MEDICINE

By

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Norman, Oklahoma
2018

SEISMOLOGY IN INDIA: COLONIAL GEOLOGISTS AND THE RAJ, 1880-1910

A THESIS APPROVED FOR THE
DEPARTMENT OF HISTORY OF SCIENCE

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Acknowledgements

First of all, I wish to express my sincere thanks to my advisor, Dr. Suzanne Moon, for working through several drafts with me, as well as for her patience, expert guidance, and thoughtful insights. I also thank Dr. Kerry Magruder and Dr. Aparna Nair. I am indebted to them for their encouragement, perspectives, and time spent helping me formulate my ideas and refine my thinking.

I also would like to thank the other faculty and staff in the History of Science department, who have helped me every step of the way. My fellow graduate students have made the time I spent in this program a joy.

Lastly, I would like to thank Taylor for his constant support and cheerful encouragement.

Aja Tolman

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Abstract

At the end of the nineteenth century, seismologists were trying to create a 'universal' seismology that could be applied worldwide. Applying the observational European techniques in various places across the world challenged scientists to reassess their methodologies, epistemologies, and evidential criteria as they realized that their methods, developed in early nineteenth century Europe, were inadequate for reading earthquake damage outside of Europe. Their decisions were directed by cultural as much as by physical considerations. Richard Dixon Oldham, a geologist working in Colonial India, used his position as a colonial scientist to argue for an instrumental turn in seismology, which privileged seismograph inscriptions over fieldwork and public observations. Embedded in this shift was the invisibility of the colonized peoples' experiences and knowledge. There was no established, standardized instrumental seismology to transition to, which indicates that seismologists believed that unreliable instruments were less problematic than unreliable people. The instrumental turn in seismology was a very deliberate, contested change, and colonial considerations played a critical role in this shift.

Chapter 1: Introduction

On June 12th, 1897, about 5:15 in the afternoon, northeast India was suddenly jolted by an earthquake. The epicenter was located somewhere in the Garo Hills, a group of hills just south of the Himalayas. Modern seismologists estimate the earthquake's magnitude to be about 8.0, and until that time, the earthquake was one of the most violent on record. An area about 8,000 square miles, roughly the size of Montenegro, was immediately devastated, with landslides stripping hills of soil, fissures opening and erupting sand and water, hills changing their elevation by several feet, and riverbanks subsiding, causing extensive flooding. Every stone or brick-built building within this radius immediately collapsed into a heap, and within a 31,000-square mile area, the buildings sustained at least substantial damage. In Calcutta, 230 miles away, residents watched as their homes split down the middle and swayed violently. The earthquake was felt over at least 1,750,000 square miles, about half the size of Europe.[1] Fortunately, most of the population was out of doors at the time, so the death rate was low relative to the violence of the quake. The official report puts the number of deaths at 1,542, which is undoubtedly too low because it was a conservative estimate that did not take into account deaths in other countries that would have been affected by the shock, such as Nepal.[2] Across India, the shocks

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[1] Charles Davison, *Great Earthquakes* (London: Thomas Murby & Co., 1936), 142.

[2] *Report on the Administration of Assam for the Year 1897-98* (Shillong: Printed at the Assam Secretariat Printing Office, 1899), i. https://play.google.com/books/reader?id=yJMAQAAMAAJ&printsec=frontcover&output=reader&hl=en&pg=GBS.PP2.

started elephant stampedes, knocked horses off their feet, and killed several fish and dolphins, whose bodies floated en masse on the Brahmaputra River that runs through the center of the Assam lowlands.[3] Few of the bodies of human casualties could be recovered, as many were buried in landslides or pulled into the Brahmaputra. For days, aftershocks continued to rock Assam.

The earthquake had damaged the water and food reserves, and unchecked disease affected many of the survivors.[4] The earthquake also damaged the colonial transportation and communication systems. The government of India rushed to repair the damage to the buildings and infrastructures, restore communication, and house the homeless Europeans. The government decided that it would be prudent to send a geologist to make a report of the earthquake. The Geological Survey of India (or GSI) had fewer than twenty members on its team to survey the entire subcontinent, but one of these was the geologist Richard Dixon Oldham (1858-1936) who had a special interest in earthquakes and who had a published on the topic. In fact, he was the only member of the GSI who had made special studies of earthquakes.[5] The GSI was a product of several attempts

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[3] Geological Survey of India, *Memoirs of the Geological Survey of India* vol. 29 (Calcutta: Office of the Geological Survey, 1889), 80. Afterwards, this memoir will be referred to simply as 'Memoir.'

[4] *Report on the Administration*, i-xiv; Memoir, 4-41, 80; "Earthquake and Elephants," *The Amrita Bazar Patrika* (Calcutta) July 26, 1897. http://infoweb.newsbank.com.ezproxy.lib.ou.edu/iwsearch/we/HistArchive/?p_product=WHNPX&p_theme=ahnp&p_nbid=K5EJ51WMMTUyNDAxNTAyOC4zMzcyNDY6MToxMjoxMjkuMTUuMTQuNDU&p_docref=v2:131DE1D267345E49@WHNPX-1467343D1F5652D8@2414132-14668E50EE36BFE0@4.

[5] Andrew Grout, "Oldham, Richard Dixon (1858–1936), geologist and seismologist," *Oxford Dictionary of National Biography*, 29 March 2018. http://www.oxforddnb.com.ezproxy.lib.ou.edu/view/10.1093/ref:odnb/9780198614128.001.0001/odnb-9780198614128-e-37820.

by the East India Trading Company (EIC) to institute a systematic survey of the mineral resources of the Indian subcontinent. Often, these surveys were conducted by army surgeons travelling with the military. In 1851, they officially instituted the GSI, and over time, the responsibilities of its officers extended far beyond a simple mineralogical reconnaissance mission.[6] Although their primary purpose was to locate valuable mineral deposits, they were also expected to make suggestions for where to build factories, lay rails, and cultivate plantations. The government relied on geologists to help map India for military purposes, educate new geologists and miners, and outline ways to make industries sustainable.[7] Assam was an especially critical area for geologists to survey, as the British discovered coal deposits, oil reserves, and a unique type of tea plant in northeastern India during the nineteenth century.[8] When the British Raj took over from the EIC in 1858, their expectations of the colonial geologists and their purpose did not change much. Geologists expressed their frustration with their overwhelming duties and disappointed hopes with the Raj's similar attitudes towards geology.[9] After the 1897 earthquake, seismological studies and surveys became new requirements for geologists. They had previously commented on the earthquakes of India, but until R. D. Oldham's memoir, none of them had

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[6] See, Andrew Grout, "Geology and India, 1770-1851. A Study in the Methods and Motivations of a Colonial Science" (doctoral dissertation, London University, 1995).

[7] See, Aja Tolman, "Geologists and the British Raj, 1870-1910" (master's thesis, Utah State University, 2016).

[8] See, Priyam Goswami, *Assam in the Nineteenth Century: Industrialization and Colonial Penetration* (Guwahati, Delhi: Spectrum Publications, 1999).

[9] Valentine Ball, *A Manual of the Geology of India, Part III: Economic Geology* (London: Trübner and Co., 1880), v.

published a full-length report on an earthquake. After the Assam Earthquake memoir, entire volumes dedicated to surveying earthquakes became a new standard for colonial geologists.[10]

This thesis explores how Oldham created his report in colonial India and how his report in turn affected the evolving discipline of seismology. Collecting earthquake data from locations all over the world was a primary concern of seismologists of the late nineteenth and early twentieth centuries. Yet seismology as practiced at the time was not yet a universal science. It only worked well in European landscapes, where buildings were made of brick and stone, where there were areas of dense population concentration, and where there was mutual trust and respect between seismologists and the public. Exporting seismology to the rest of the world challenged seismological practice on all of these points. Seismologists were forced to reassess their methodologies, epistemologies, and evidential criteria in the face of this "globalization" of their science. Oldham's report and the subsequent methodologies he recommended embedded within them assumptions about the inferiority of Indians, especially their ability to be scientific observers, and the inferiority of their architecture. As one of the few seismological reports from a colonial "outpost," seismologists in Europe used Oldham's report in the already-existing debate over how to calibrate seismology so that it could be used across the world. Oldham's report advocated for the instrumentalization of seismology, which would take the power of observing

[10] For example, see, Geological Survey of India, *Memoirs of the Geological Survey of India* vol. 38 (Calcutta: Office of the Geological Survey, (1910).

earthquakes out of the hands of Indians and put it into the hands of a few instrument observers, rendering Indian knowledge and knowledge-makers invisible. He based his new methodology on social as much as physical considerations.

Details about the earthquake appear in several types of sources, including photographs, government reports, newspaper and magazine articles, narratives, letters, and expense reports. These sources show not just the official and political aspects of the reports, but also the public responses to the disaster in both India and Britain. The photographs reveal how people visually documented an earthquake, and the newspapers reveal the confusion immediately following it. Although I will be using these sources, the primary source for this thesis is the official scientific report that Oldham submitted to the colonial government. A close reading of this text reveals subtle clues about how Oldham changed Mallet's methodology to fit the colonial situation, both out of physical necessity and social and political considerations. His text reveals how he collected information, including what types of questions he sent out and what he was looking for in observations. The letters in the report also reveal how Oldham wanted people to observe earthquakes. The evidence informants submitted varies widely, from reporting the weather the days before the earthquake to writing that at first, they thought the ground movement of the earthquake was caused by elephants bathing in a pool.[11] It shows how the government tried to make sense of the disaster, and

[11] Memoir, 9, 39.

what they expected a "scientific point of view alone" to look like.[12] The report is a good example of how abstract theories translated to on-the-ground practices.

Oldham intended the report to be accessible to scientists and the general public alike because, he said, of the general interest in the earthquake.[13] And it is certainly true that this was a highly respected and influential report, becoming a well-known text, and making Oldham himself famous. The report is over 400 pages long and includes a wide variety of evidence. Oldham includes descriptive letters, responses to his circulars, photographs, maps, sketches, mathematical formulas for analyzing pillar rotation, other geologists' reports, his own observations, and detailed analysis of each observation. Charles Davison (1858-1940), a seismologist and mathematician, mentions it several times in his works, saying that it was the work Oldham was best known for, and that as an earthquake survey, it was the "most careful and detailed that we possess."[14] It also "far surpassed in quality all reports on previous earthquakes."[15] Although he was actually a geologist, he was primarily known for his contributions to seismology, primarily because of his 1899 report and his 1900 theory of earthquake waves.

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[12] Memoir, 2.
[13] Memoir, v.
[14] Charles Davison, "Richard Dixon Oldham," *Obituary Notices of Fellows of the Royal Society* 2, no. 5 (Dec. 1936): 111. http://www.jstor.org/stable/769131; Davison, *Great Earthquakes*, 139.
[15] "Oldham, Richard Dixon," in *Complete Dictionary of Scientific Biography*, 203. Vol. 10. Detroit: Charles Scribner's Sons, 2008. *Gale Virtual Reference Library* (accessed March 29, 2018). http://link.galegroup.com.ezproxy.lib.ou.edu/apps/doc/CX2830903221/GVRL?u=norm94900&sid=GVRL&xid=168af9d2.

As the recent work on earthquakes by historians shows, the meanings of earthquakes vary widely across time and space. They are not simply geological events. They are imbued with meaning, whether that meaning is social, economic, political, scientific, or religious, or a combination of all these elements. Defined as disasters, the meaning of earthquakes is deeply anthropocentric. They tend to exaggerate existing social and political tensions, providing a unique way to look at issues that were often simmering just beneath the surface.

The historiography of earthquakes involves works that approach the subject from several analytical frameworks. Deborah Coen, in *The Earthquake Observers*, takes an intellectual and social history approach, exploring how observing and reporting earthquakes was a process of negotiation and translation between seismologists and the public. Conevery Bolton Valenčius and Charles Walker, in *The Lost History of the New Madrid Earthquakes* and *Shaky Colonialism*, use cultural and political history frameworks, showing how the populations affected by the earthquakes made sense of and interpreted the disasters in the midwestern United States and Peru. Gregory Clancey tackles the history of earthquakes in late nineteenth and early twentieth-century Japan using architectural history as his lens in *Earthquake Nation*. By focusing on the anthropocentric nature of disasters, the histories center the human experiences of earthquakes. Similarly, all show that public engagement characterized the history of early seismology. The public constructed the meaning of earthquakes but also came up with their own methods of observation and verifications. Professional researchers attempted to tap into, direct, and control these networks of information. Their success largely depended on the trust and communication they established. The books that deal with later seismology show how these public observations and the two-way communication subsequently broke down, both for external sociotechnical reasons and the internal mechanization of the field. Science in the colonial state, as a secondary theme in a few of the books, addresses how colonial 'outposts' helped structure seismology.

All share the anthropocentric focus of earthquakes-as-disasters. Each book shows how survivors and observers constructed how to 'properly' observe and interpret an earthquake. Coen reminds her readers that the "unabashedly anthropocentric" nature of nineteenth century seismology studied earthquakes' impact on humans and had "human interests at heart."[16] Because of this focus, she explores how people observed earthquakes throughout Europe, the western United States, and Samoa, contrasting the differences as relationships between the public and the seismologists shifted. In one example, Coen shows how Swiss seismologists particularly valued women's observations because women were supposed to be far more sensitive than men.[17] Walker shows how as the eighteenth century Lima administration and public were trying to understand who to blame for the earthquake, they created legislation that limited the mobility and visibility of women and the indigenous population. Their efforts were primarily preventative, to stop God from sending another earthquake and tsunami, so pinpointing the exact cause of the earthquake and whom it affected most was

[16] Deborah Coen, *The Earthquake Observers: Disaster Science from Lisbon to Richter* (Chicago: The University of Chicago Press, 2013), 11.
[17] Coen, *Earthquake Observers*, 86.

essential. Valenčius examines how the public constructed a narrative of the 1811-1812 New Madrid earthquakes in the absence of a governing scientific authority. They decided their own criteria for observing the earthquakes and aftershocks and verified their results through correspondence and newspapers. The earthquakes, Valenčius also claims, helped start the Great Revival as well as prompted some Native American revolts against the western-moving whites. Clancey shows how the Japanese used the several earthquakes of Japan and their newly developed methods of observation to fashion themselves as an 'earthquake nation' at the forefront of research. In each of these books, earthquakes were not simply events. They had religious, moral, and political meaning in addition to the supposed scientific meaning.

Because of this multifaceted construction of meaning, the authors focus on the public participation in observing and constructing meaning. Scientists, as Coen explains, did not know how to gather observations from the public any better than the public knew how to observe earthquakes 'scientifically.' Through multiple trial and error efforts, the Swiss and Austrian scientists established public education, and in return, they used their conclusions to benefit the populations that submitted observations. Though these European countries established good methods of communication between public and professional, other places in the world, like Samoa and Great Britain, were less successful. British earthquakes became something of a joke and in Samoa, Samoan participation did not matter much at all. Earthquake observation techniques varied widely across place, and much of it was dependent on the degrees of trust between scientists and the public. However, Coen points out, seismology was absolutely bound by the experience of people and in willingness to observe. Valenčius' book is, primarily, the story of an American public science operated almost independently of any scientific authority. The earthquakes reveal "what science really was in the early United States: a set of questions and debates in which many people, from a wide range of geographic and social places, regarded themselves as engaged participants."[18] The earthquakes, at the time, were one of the greatest unifiers of the public who engaged in constructing how to observe earthquakes.

Valenčius' story is also one of how these earthquakes were subsequently forgotten. The process of silencing public observations is another theme that many of the authors address. Coen and Clancey both examine how scientists tried to use mechanization to make the public voice unnecessary. Clancey shows how turning to instruments in Japan was the way that seismologists tried to make their science commensurable and competitive with European seismology, while Coen explores how the instrumental turn was an effort to unmake earthquakes as disasters, which led to a breakdown of two-way communication between scientists and the public. Valenčius, however, looks at the specific processes that led America to forget the earthquakes. She identifies sociopolitical problems, such as the Civil War and selling the Midwest as a site of grain production, as a few of the specific reasons the earthquakes and their observers were made invisible in history. Valenčius also identifies the simple problem that "they do not in any way

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[18] Conevery Bolton Valenčius, *The Lost History of the New Madrid Earthquakes* (Chicago: University of Chicago Press, 2015), 11.

resemble our usual histories of science" and so were not included in the history of science narrative.[19] As her title implies, this history was lost.

Although usually a secondary argument, most books deal with colonialism as a factor in the history of seismology. Clancey and Walker tackle this directly. Walker examines how colonial anxieties revealed by the earthquake shaped subsequent policies of racial segregation and city building. Clancey shows that in the Japanese case, the clash of East and West led to the collaborative creation of a new type of seismology, seismographs, and aseismic structures. For Clancey, conducting seismology outside of the West was fundamental in the development of modern seismology. It was an important part of 'calibration,' a term Kapil Raj uses to describe the process of making fieldwork-based scientific disciplines globally applicable.[20] Colonialism is less conspicuous in Coen's and Valenčius' books, though Valenčius notes that the indigenous populations saw the earthquakes as a sign of displeasure that the Europeans had settled on Native American land, which led to conflict. Coen also addressed the role of colonialism, using the Samoan outpost as an example of the Europeans' dedication to gathering data worldwide. The colonial question and locations, Coen believes, shaped the direction of seismology. Each show that encountering other cultures and locations while gathering data and assigning meaning profoundly affected the formation seismology throughout the history of earthquake observation.

[19] Valenčius , *Lost History*, 11.
[20] Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe*, *1650-1900* (New York: Palgrave Macmillan, 2007.)

Looking at the history of seismology in Colonial India reveals many of the same themes. European seismologists in India had to determine what type of relationship they needed to establish with the Indians. Unlike most of the other books, seismologists actively downplayed the amount of public participation contained in their surveys. This thesis explores some possible motivations for this relationship between seismologists and the public. It looks at how the scientists structured public participation and which people were allowed to participate in creating the 1897 earthquake narrative. In addition, it examines what a 'scientific' earthquake report was supposed to look like, and this mostly meant that the human element was eliminated or hidden. The process of silencing the public is a major theme, as colonial scientists in India attempted to undermine, control, and categorize the Indian observations and reactions. Oldham's argument for the instrumental turn in seismology was based primarily on the supposed unsuitability of colonial subjects as scientific observers. This story particularly challenges Clancey's narrative by providing an alternate example of how the construction of seismology unfolded differently under a different power hierarchy, funding model, and government response. Instead of taking a collaborative approach like the scientists did in Japan, India is an example of an explicit rejection of collaboration in favor of making seismology more eurocentric and exclusive to trained seismologists.

Part of the problem of the historiography is the dependence on the outdated histories of seismology written by Charles Davison in the early decades of the twentieth century. By adopting these narratives uncritically in their books, a few of the authors also adopt Davison's triumphal tone of technological determinism, explaining that once seismographs were good enough to replace human observers, seismologists adopted them unquestioningly.[21] This thesis challenges this narrative by taking a history of science and technology approach and recentering the history of seismology and seismographs. By looking at the contested transition to the 'new' seismology, it takes into account the role that colonial scientists played in pushing for the transition.

The first chapter explores how Oldham conducted his survey in Assam. Since his methods worked only if there were European structures and infrastructures, most of his report is an assessment of how the earthquake damaged the British empire in India. His report focused on imperial architecture, railways, telegraphs, and time. The tool he relied on most was the imperial communication network. However, his report would have been sadly incomplete if he had only relied on the evidence from the damaged empire. He also relied on Indian observations and observational techniques, which he incorporated into his report. However, keeping the international and colonial audience in mind, Oldham tried to disguise the origins of these Indian-specific methods, and developed a fixation on verifying any Indian evidence with his own observations. The Indians' structures mostly escaped damage from the earthquake, and the Indians were able to quickly recover from the earthquake's devastation. However,

[21] Coen is the author that discusses the transition from observational seismology to the 'new' instrumental seismology. However, she takes an approach that emphasizes that the point of contest was a question of social responsibility rather than analyzing the history of the instruments themselves.

this flexibility meant that the greatest strength of their structures, their ability to withstand earthquakes, was something that Oldham did not know how to read as scientific data. His modified methodology was based on both physical and social considerations, including adjustments to intensity scales and evidence. This resulted in an invisibility of Indian bodies and observations. Making seismology a universal science, Oldham argued, required seismologists to transcend, rather than embrace, the particularities of each location. Instead of being a transcendent science, however, his methods further insulated European seismology from the rest of the world, privileging European data, instruments, and epistemologies.

The second chapter looks at how this report functioned as an argument in larger seismological debates and influenced the direction of the field. Seismographs were unreliable instruments, as seismologists were still constructing the definition of what a good seismograph measured and what an accurate seismogram looked like. Still, Oldham argued that because of the difficulties of colonial seismology, instruments were naturally a better alternative as they lessened seismologists’ dependence on the public and separated them from the varying demands of regional fieldwork. Being one of the few reports from colonies, Oldham’s work was an important perspective that seismologists considered when deciding how to make seismology a universal science and whether seismology should position itself as a subdiscipline of geophysics. His later work confirmed his suggestions, as he used inscriptions from seismographs to provide the first instrumental proof that the earth had a core and that there were three distinct types of earthquake waves. Compared to Japan, this section shows that Oldham's way of universalizing seismology was not the only way, as the Japanese took a different approach to making seismology fit their country's needs.

Chapter 2: Observational Seismology in Colonial India

In 1897, seismology was a relatively new discipline, being only about forty years old.[22] At this point, most seismologists used the method called observational seismology, which meant that they used observations of the secondary effects of earthquakes, such as damage to buildings, to draw inferences about the origin, intensity, and direction of the shock. Robert Mallet (1810-1881) laid the foundations for this method in his famous 1862 book *Great Neapolitan earthquake of 1857: The First Principles of Observational Seismology.* Seismologists (a term Mallet also invented) across Europe and Japan used his method to document their own earthquakes. Observational seismology was far from universal, however. Developed in Europe, it was deeply tied to the landscapes of its origins. It relied on the assumptions that surveys were being conducted in Europe, where many homes were built of brick or stone, where there were areas of dense population, and where there was mutual respect and trust between seismologists and the public. R. D. Oldham found that this method was a remarkably inadequate fit for India. With the variations in architecture, language, and power hierarchies, India seemed to rebuff attempts to capture her earthquakes in scientific surveys. Only British colonial structures and infrastructures yielded information that fit within Mallet's guidelines.

[22] Robert Mallet, *Great Neapolitan Earthquake of 1857. The First Principles of Observational Seismology as Developed in the Report to the Royal Society of London of the Expedition Made by Command of the Society into the Interior of the Kingdom of Napes, to Investigate the Circumstances of the Great Earthquake of December 1857*, volumes 1&2 (London: Chapman and Hall, 1862.) https://hdl.handle.net/2027/mdp.39015064473799.

Oldham's primary concern was to make a seismology that worked in colonial landscapes. Faced with problems that the field had not yet addressed, Oldham modified seismology according to social, political, and physical considerations. Instead of trying to create a hybrid science, one that drew on the strengths of European seismology combined with local indigenous knowledge for a new method specially produced to make use of the unique circumstances, Oldham stripped observational methodology down to its most basic form, eliminating the primary place of human reactions and public observations in scales and maps. In other words, he tried to eliminate everything that was 'Indian' about the Indian earthquake, framing his survey as something that was conducted *despite* the location. This colonial seismology made it more difficult to compare the Assam earthquake to other earthquakes around the world, was less specific and informative than most other earthquake surveys, and rendered the Indian voice invisible.

Oldham would not have been able to conduct one of the most important and influential seismological surveys of the nineteenth century if not for the colonial architecture, infrastructures, and practices that had come with the colonization of India, structures which his methodology told him how to read. The railways, telegraphs, steamships, architecture, and tea plantations all gave Oldham ways to 'see' the earthquake. Both the destruction and functioning of these technologies and systems gave Oldham most of the tools he needed to conduct the survey. However, they also made the earthquake more costly, disruptive, and deadly. Railways, telegraphs, and damaged buildings required extensive and expensive repairs. Stone buildings collapsed on their inhabitants, crushing them. And the deforestation and increase in population due to tea plantations made it possible for hundreds of people to die in the lowlands near the Brahmaputra River.

The structures of the Indians, on the other hand, were developed to survive earthquakes. Although more than 1,540 Indians died (as opposed to only 2 Europeans), the Indian population as a whole was able to recover from the earthquake much more quickly than the Europeans. The amount of destruction caused by the earthquake seemed directly proportional to the adoption of European structures; the earthquake was far more devastating for Indians who had incorporated European elements, such as chimneys. As a consequence, the earthquake affected the wealthier population of India more acutely than the poor as the wealthier population had been more able and, in many cases, more willing to adopt the European architecture and lifestyle. It drew a clear line between the colonizer and the colonized and exposed the fragility of the empire to natural disaster.

Although the embodiment of colonialism in technologies, masonry buildings, and transportation and communication systems were Oldham’s most important tool, it would be a mistake to overlook the essential contributions by the Indians. Despite his efforts to maintain a strict distance from Indian information, the size of the subcontinent, the peculiarities of the specific regions, and the transient but landscape-altering nature of the earthquake shock necessitated his dependence on information and observational techniques gathered from Indians.

For him, this dependence on human testimony was one of the biggest flaws of his report. He tried to remedy this by burying their contributions under his own observations and quietly incorporating their techniques for tracking earth movement.

Oldham could not escape the differences between conducting an observational seismological survey in Europe and conducting one in India. Mallet's seismological methods required extensive modification for use in India. Oldham relied both on Indians' testimonies and observational techniques to complete his survey. Their methods were subsumed into Oldham's methodology, but the origins of these methods were deliberately obscured by Oldham in an effort to appear more objective in his reports. Collecting evidence from colonized people and writing a report about a colony meant that Oldham had different priorities than a seismologist observing and writing about Europe. Oldham decided to reinforce the hierarchical power structure in his presentation of the report. Indian voices and evidence fade into the background or are remanufactured into fearful, unscientific commotion, while the triumph of the European over difficulties shines. Cognizant of his target audience, other European seismologists and the general public, Oldham made it a priority to verify each Indian report he included (European evidence was not subjected to the same rigorous standard) and downplay the major role the Indian observers had in creating this report.

Mallet, Observational Seismology, and India

In 1857, Robert Mallet (1810-1881) penned a letter to the Royal Society, requesting funds to travel to Italy to study the large earthquake that had just devastated the southern part of the peninsula.[23] In the letter, he described his method for studying the earthquake based on observing the secondary effects. He laid out the method in his famous book, *Great Neapolitan Earthquake of 1857: The First Principles of Observational Seismology.*

> Other [phenomena and effects] are more or less permanent, and, from the terrible handwriting of overturned towns and buildings, may be deciphered, more or less clearly, the conditions under which the forces that overthrew them acted, and velocity with which the ground beneath was moved, the extent of its oscillations, and ultimately the point, can be found in position and depth beneath the earth's surface, from which the original blow was delivered, which, propagated through the elastic materials of the mass above and around, constituted the shock. Again, certain effects, such as landslips, fissures, alterations of water-courses, &c., are produced of greater or less permanency affecting the natural features of the shaken country.[24]

By observing these semi-permanent effects, a trained seismologist could produce a scientific map and report about an earthquake soon after it had happened. A well-conducted survey was meticulously detailed and thorough. For example, observers should note, and sketch or photograph, if possible, the cracks and damage to walls and record the direction structures fell. They should also record building material, general condition, number of openings (for doors and windows), dimensions, foundation materials, and any other relevant information about affected buildings. An observer should weigh and measure projected

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[23] Mallet, *Great Neapolitan Earthquake*, vii-x.
[24] Mallet, *Great Neapolitan Earthquake*, 6.

bodies, chemically analyze gases and material that erupt out of fissures, time and measure seas and sound waves, record the reactions of animals, and explain local geological conditions. They also needed to document landslides fissures, changes to river-courses, tide levels, dead animals (especially fish), and meteorological information like rainfall and temperature.[25] Almost every detail was relevant to an earthquake report.

Seismology also relied on information gathered from those who had experienced the earthquake. These public observers wrote to seismologists, telling them of their own personal impressions of the earthquake, such as the time they first felt it, how long it lasted, what direction the waves seemed to be moving in, the general type of movement (waves or jolt, for instance), and any proof they could come up with to corroborate their claims. These collections of observations were goldmines for seismologists, who depended on them to complete their analyses.

Mallet also included information instructing people in how to make what he called seismometers, or instruments that measure earthquakes. Making seismology an instrumental science was a goal from the very beginnings of the discipline. The data gathered from various types of seismometers was also included in earthquake reports, but they did not have a privileged place. Rather, they were usually included towards the end to provide extra evidence for an observer's conclusions.

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[25] Herschel, *A Manual of Scientific Enquiry,* 223-36.

As he had hoped, Mallet's methodology became the default method for seismologists around the world, although each put their own twist on it according to the constraints of the areas in which they worked.[26] His invention of isoseismal maps became an important part of reports. Intensity scales also began to appear. The purpose of the maps and scales was to be able to compare earthquakes. Mapping and documenting earthquakes across the world and across time became the primary objective of seismologists. Their goal was to understand the global mechanics of the interior of the earth.

Observational seismology made its way to India through Thomas Oldham (1816-1878), the director of the GSI and father of R. D. Oldham. The GSI struggled the first two years of its existence, as its directors kept dying or retiring. It was not until Thomas Oldham took over the survey in 1852 that it began to get organized. Eventually, it was labelled a "premier scientific institution."[27] Its primary purpose originally was to map and report on the economic, military, and political value of the subcontinent. While working on this map of India, he turned his attention and efforts to seismology. This interest and study started in 1869.

While sitting in a house near Calcutta, quietly reading to himself, Thomas Oldham felt the ground underneath him lurch.

> [W]ithout any warning, the chair was violently rocked under me, everything in the room was shaken, doors and windows rattled and the chandeliers hanging from the ceiling were set swinging with considerable force. At once noting the time of the shock by my own watch, and just

[26] Mallet, *Great Neapolitan Earthquake*, 9.
[27] Deepak Kumar, "Economic Compulsions and the Geological Survey of India," *Indian Journal of History of Science* 17, no. 2 (1982): 290.

> then feeling a second but less violent shock pass under me, I got up to see more particularly what had occurred.[28]

He watched as furnishings swayed and listened to the shouts of people in the bazaar. The 1869 Cachar Earthquake, which occurred about 300 miles away from where Thomas Oldham was staying, sparked his interest in seismology. After carefully reading Mallet's report, Oldham undertook a small survey of the earthquake. He also catalogued all of the historical Indian earthquakes of which he could find record. Before his works were printed, he retired to Britain and died soon after in 1878. It was his son, R. D. Oldham, who edited his father's records of the earthquakes and published them in an edition of the *Memoirs of the Geological Survey of India*.

R. D. Oldham also developed an interest in seismology and continued his father's work on earthquakes. Like his father, he used Mallet's observational seismology, although he included all the most recent theories and methods in his report as well, as seismology was a rapidly growing field. When the 1897 Assam earthquake struck, his knowledge was stretched to the limit. He was the geologist who was assigned to survey the ruins left by the earthquake and publish a report. Oldham took two years to complete the report, as the survey required not only gathering observations, but also computing mathematical calculations. Several of his many publications (over ninety) dealt with seismology theory and fieldwork.[29]

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[28] Geological Survey of India, *Memoirs of the Geological Survey of India* vol. 19 (Calcutta: Office of the Geological Survey, 1883), 1. https://hdl.handle.net/2027/mdp.39015035542151.
[29] Ibid.

Observational Seismology in India: Architecture

According to Mallet's book, damage to architecture was one of the most valuable indices of an earthquake's strength and direction. By assessing the damage to each building, a seismologist could guess how near to the epicenter the building was, along with the direction and possibly even type of wave, that passed under the damage building. By observing groups of damaged buildings, a seismologist would then be able to make a map of how the damage of an earthquake changed as it moved through the ground. This map, called an isoseismal map, was a key document that seismologists were supposed to produce in an earthquake report. The type of damage, and buildings' susceptibility to it, was key in presenting this method of survey. European architecture was rare in northeastern India. Oldham could not observe architectural damage in the same way he would have been able to in Europe, and architecture overall was not very helpful in building the report, besides the drawing of the isoseismal map. There were a few European-style houses scattered across Assam and Bangladesh, but the majority of the buildings were built in the Indian style. The Indians' houses, and specifically the houses of the Garos and Khasi, withstood the earthquake much better than any of the masonry constructions, most of which were owned by Europeans.

The typical Indian house in Assam in 1897 was labelled the *ekra*, or *ikra*, house, named after the reed that grew locally. These houses had lightweight bamboo frames and were covered in *ikra* mats. The *ikra* was then coated in plaster. The house rested directly on a stone or earth foundation; their frames were not sunk into the ground for stability. Some of these houses had masonry chimneys. These usually did not survive the earthquake.[30] When the shock hit the house, the chimney collapsed onto the delicate frame, smashing it. In most cases, however, the Indians lived in small, chimney-free houses. Although all houses very near the epicenter of the earthquake collapsed, most Indian houses survived the earthquake with minimum damage. The most common complaint was that all the plaster got shaken into pink dust which clouded the air around the villages.[31] The Garo houses were even more capable of tolerating the earthquake. These houses did not have plaster coatings, had "a raised floor and [were] built entirely of wood, bamboo, cane, and thatch. These houses, when on level ground and in fairly good repair," Captain A. A. Howell reported, "have not been at all affected by the shaking."[32]

Most Indian houses were not destroyed by the shock of the earthquake itself. Landslides were the greatest threat to these homes. Many of the houses were built on hillsides or up against a cliff, so when the earthquake shook the earth underneath them loose, they were carried off of the hillside or were crushed underneath the debris that fell off of the cliff. This is how most of the earthquake victims died. In other parts of Assam, the houses in the lowlands were carried into the river when the riverbank subsided. For others, the ground liquified underneath them during the earthquake, which caused them to sink up to their roofs in the

[30] Memoir, 282.
[31] Memoir, 5.
[32] Memoir, 13.

liquid earth.[33] If they escaped landslides and liquefaction, the Indian houses tolerated the earthquake well, except for the loss of the plaster coating. They had not, however, been affected by the earthquake in any way that Oldham could use for his report. The house had either stood or crumbled into a heap, providing no indication of the direction, intensity, or type of waves. They were also quick and easy to assemble, relative to stone or brick buildings, so many of the collapsed houses had been repaired or replaced by the time Oldham or another GSI geologist had a chance to survey the damage. Damage to the average Indian house, then, could not be used as a seismological index. The very durability, flexibility, and simplicity of construction which made it ideal for a seismic country also made it unsuitable for Western seismology. Observational seismology depended on the western assumption that structures were aseismic and would sustain more or less permanent damage from an earthquake. Oldham and other seismologists relied on masonry buildings to 'see' an earthquake. The Indian home could not capture a snapshot of an earthquake the same way that masonry homes could.

Although Indian-style buildings were not an important feature in earthquake reports, their resiliency and easy construction caught the government's attention. After the earthquake, the government decided to change the way it built structures in Assam. The Assam officials noted that they reconstructed houses and government buildings, such as jails, in the *ekra* style, both to save on cost and to

[33] Memoir, 5-6.

prevent further future damage by earthquakes and aftershocks.[34] The British began adopting the Indian style of construction to prevent such large-scale destruction and loss of life in the future. There was never any acknowledgment that the Indians knew better ways to live in a seismic area than the British did. None of it was attributed to Indian ingenuity or experience. Most of the time, officials justified their change in building tactics by citing cost savings. Instead of simply building inexpensive Western-style wooden houses, however, they styled their new structures after the Indian houses. But these houses, instead of being thought of as especially aseismic structures, were thought of as inferior to English style. They were rarely referred to as houses, most often being termed 'huts.'[35]

In the Indian memory, by contrast, the Indian-style houses and the British adoption of this construction style continues to be a source of national pride. Jai Krishna, an engineer, wrote that Indians had developed their building style because of centuries of observations.[36] Sanjoy Hazarika, in a 2015 newspaper article, attributed the increasing number of concrete buildings to man's arrogance, advocating for a return to the Assam-type house.[37] Even though the British never verbally praised the Indian methods of building, their allocation of funds and changes in building policy revealed the reluctant acknowledgment of aseismic Indian buildings.

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[34] *Report on the Administration*, xiii.
[35] Memoir, 17, 22-23, 259, 280, 289, 295, 310.
[36] Jai Krishna, "Development of Earthquake Engineering Studies in India," *Journal of the Indian Geophysical Union* 7, no. 3 (October, 1970): 59.
[37] Sanjoy Hazarika, "The Assam Type House," *The Indian Express*, April 30, 2015, http://indianexpress.com/article/opinion/columns/the-assam-type-house/.

The few European masonry homes and buildings, unlike the majority of Indian homes, were severely damaged, if not completely destroyed, by the earthquake. In Assam, all masonry and brick buildings were total losses. They crumbled into stone mounds, burying any of their inhabitants who had not managed to escape in time. In Calcutta, European houses were constructed in a particular European style that was especially weak against earthquake movement. Their weight and proportion were not evenly distributed across the house itself, resulting in points of weakness. They split down the middle, repeatedly separating and crashing back together as each wave hit them.[38] Although the Calcutta houses did not have much irreparable damage, the repeated smashing together of the split-open houses was a terrifying spectacle. Only two Europeans died during the earthquake: Mr. R. B. McCabe, the Inspector General of Police and Jails, and Mr. Rossenrode, "a pensioner of the Survey Department."[39] Both died after their homes collapsed and crushed them.[40] The Assam police department spent the first hour after the earthquake digging out McCabe's body from the rubble as his wife looked on.[41] Many Europeans who lived in stone or brick homes were left homeless after the quake. The weather had been remarkably hot, and there were heavy rainstorms in Assam when the earthquake took place, although they had not

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[38] Memoir, 45.
[39] *Report on the Administration*, i.
[40] Ibid.
[41] "The Earthquakes in India," *The Manchester Guardian* (Manchester, UK) August 11, 1897.
https://search.proquest.com/docview/483434577/615EF02E4FF94E14PQ/37?accountid=12964.

yet reached monsoon season.[42] Aftershocks continued to shake Assam daily for over two years following the disaster, and immediately following the earthquake there was an aftershock about every ten minutes.[43] Unsurprisingly, the people living in Assam avoided the ruined masonry houses and opted to take shelter in Indian *ekra* or Garo outbuildings, such as stables. Still others preferred to sleep on the cricket field in the rain because they were afraid to return to a structure that might collapse on them in their sleep, even if it was an *ekra* building.[44] The lightness of the Garo houses made them fairly safe; even if they did collapse they likely would not kill their occupants.

The earthquake drew a rather distinct line between the relatively resilient Indian houses and the rigid European houses. As the Assam Administration noted,

> [i]t soon became apparent that the catastrophe was one which had principally affected the wealthy and well-to-do classes of the community, who reside in masonry buildings. The poor, who live in mat huts, did not suffer very much…But from whatever point of view it may be regarded, the losses sustained by the people of Assam in consequence of the earthquake must be considered immense, and among the wealthy and comparatively well-to-do the loss and suffering were acute.[45]

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[42] "India's Severe Earthquake," *New York Times* (New York) June 15, 1897. https://search.proquest.com/docview/95453073/615EF02E4FF94E14PQ/36?accountid=12964; "The Indian Shakes," *Los Angeles Times* (Los Angeles) June 19, 1897. https://search.proquest.com/docview/163833536/615EF02E4FF94E14PQ/33?accountid=12964.

[43] *Report on the Administration,* i.

[44] "The Earthquakes in India," 1897.

[45] *Report on the Administration,* ii. It should be noted that though they do not specify, the Administration is talking about the financial implications. Most of the victims who died because of the earthquake were from the lower classes, being crushed in a landslip or drowned in a river.

A wealthy Bangladeshi also noticed the divide between the wealthy and poor. "The upper classes I may say have suffered the most, and the lower classes the least."[46] Because the British, Indian, and Bangladeshi upper classes lived in masonry buildings, the earthquake showed a rather stark difference between colonizers and colonized, wealthy and poor.

The poor Indians noticed this too. Captain A. A. Howell, who wrote a letter about the earthquake, was concerned that the alleged rumor that Queen Victoria ordered the earthquake would prompt Garos "without a doubt" to cause trouble.[47] He attributes the lack of trouble to the European officials' wrecked houses in Tura. Howell implied that after observing the demolition of the imperial buildings, the Garos concluded that the Queen would not have ruined her own peoples' buildings.[48]

Although both the Indians and the British generally divided the houses into masonry (damaged or destroyed, Western) and Indian (undamaged, Oriental), the distinction between the levels of damage and the types of houses was not as sharp as they imagined it to be. Several Indian houses collapsed, and several strongly built masonry buildings a good distance from the epicenter remained standing even if the houses near them collapsed. Many mosques and Hindu temples were built of stone, and several collapsed with the earthquake. Oldham, however, could not read the Indian architectural damage. He did not have the framework or architectural knowledge to turn this into data. However, the

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[46] Memoir, 23.
[47] Memoir, 14.
[48] Memoir, 14.

majority of the masonry or brick buildings in 1897 were British. “In India, kiln-break structures laid in lime mortar were limited to churches, government, and railway buildings and in rural center chiefly to factories and tea estates.”[49]

Although it lay outside the British empire, Tibet also had several stone buildings, especially Buddhist monasteries, which were affected by the earthquake.[50] Because Oldham could not easily travel to and survey Tibet or the Himalayas, he could only make a guess about the damage caused there. However, because the buildings were made of stone, he would have been able to ascertain the direction and intensity of the earthquake in Tibet after it had passed under the Himalayas. In this case, politics were as much a boundary to observational seismology as any physical barrier. He did not, however, pay much attention to the Hindu or Muslim buildings that were made of stone that he had access to, so it is doubtful that he would have made better use of the Tibetan temples. One possible reason for this omission is that he was familiar with the architectural design of Western buildings, including their strengths and weaknesses. Using Indian stone buildings in his report would have required him to become familiar with Indian architecture. However, Oldham did not use the damage to these temples as his primary data, contrary to observational seismology’s methods. He noted them, but often only whether they were damaged. Some of the other

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[49] Nicolas Ambraseys and Roger Bilham, “Reevaluated Intensities for the Great Assam Earthquake of 12 June 1897, Shillong, India,” *Bulletin of the Seismological Society of America* 93, no. 2 (2003): 658, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.821.838&rep=rep1&type=pdf.

[50] Ambraseys and Bilham, “Reevaluated Intensities," 657.

geologists, like Thomas Henry Digges La Touche (1856-1938; the only geologist near Assam during the earthquake) carefully documented these temples and the damage they observed. Oldham included these observations in an appendix but did not comment on them further.[51]

His methodology constrained him to observing masonry buildings, so he needed to make some adjustments to the seismology. He modified the scale to better fit the conditions of India.

> In a closely populated and civilised country, where most of the buildings are of brick or stone, this was possible, but the area over which this earthquake was felt is a largely wild, thinly populated country, and even in the thickly populated parts brick and stone buildings are rare and widely scattered. As a result it has been found impossible to attempt to define more than seven degrees of intensity...[52]

The modifications enabled Oldham to draw the isoseismic map. His modified scale eliminated most of the human elements of Rossi-Forel Scale; the most he included was that the earthquake was "universally felt," "generally noticed," and "noticed by a small proportion of people."[53] By removing the human element, and

[51] Memoir, 266, 275.
[52] Memoir, 42
[53] Memoir, 43. Oldham's scale is as follows: "1. The first isoseist includes all places where the destruction of brick and stone buildings was practically universal. 2. The second, those places where damage to masonry or brick buildings was universal, often serious, amounting in some cases to destruction. 3. The third, those places where the earthquake was violent enough to damage all or nearly all brick buildings. 4. The fourth, those places where the earthquake was universally felt, severe enough to disturb furniture and loose objects, but not severe enough to cause damage, except in a few instances, to brick buildings. 5. The fifth, those places where the earthquake was smart enough to be generally noticed, but not severe enough to cause any damage. 6. The sixth, all those places where the earthquake was only noticed by a small proportion of people who happened to be sensitive, and being seated or lying down were favourably situated for observing it." Memoir, 43.

many of the other descriptions that would be appropriate for most European villages, his scale was not necessarily adapted for India as much as pared down to be suitable to almost any settings. He attributes the necessary modifications to the Rossi-Forel Scale to the lack of and distance between masonry buildings.[54]

Since it was necessary to make his report comparable with other surveys, Oldham restricted himself to analyzing and mapping Western-style masonry buildings. Calibrating observational seismology to the Indian landscape, for him, meant eliminating the unique characteristics of India. He did not add to the scale, only subtracted from it. The scale as a tool of the seismologist, then, was still essentially eurocentric. It could reflect xonly the damage to the colony instead of measuring intensity across the subcontinent, including new methods of observation. Calibrating the seismological intensity scale outside of Europe

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[54] The Rossi-Forel Scale: I. Microseismic tremor. Recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds. The shock felt by an experienced observer. II. Extremely feeble tremor. Recorded by several seismographs of different kinds. Felt by a small number of persons at rest. III. Feeble tremor. Felt by several persons at rest. Strong enough for the direction or duration to be appreciable. IV. Slight tremor. Felt by persons in motion. Disturbance of movable objects, doors, windows, cracking of ceilings. V. Moderate tremor. Felt generally by everyone. Disturbance of furniture, ringing of some bells. VI. Strong tremor. General awakening of those asleep. General ringing of bells. Oscillation of chandeliers, stopping of clocks, visible agitation of trees and shrubs. Some startled persons leaving their dwellings. VII. Very strong tremor. Overthrow of movable objects, fall of plaster, ringing of church bells. General panic. Moderate to heavy damage buildings. VIII. Damaging tremor. Fall of chimneys. Cracks in the walls of buildings. IX. Devastating tremor. Partial or total destruction of buildings. X. Extremely high intensity tremor. Great disaster, ruins, disturbance of the strata, fissures in the ground, rock falls from mountains. C. D. P. “The Rossi-forel Scale of Earthquake Intensity.” *Publications of the Astronomical Society of the Pacific* 7, no. 41 (April 1895): 123-125. http://www.jstor.org/stable/40670542.

stripped it of most of its descriptors and four of its levels, leaving it a less effective tool for making a useful worldwide map of earthquakes.

Observational Seismology in India: Infrastructures

Since architecture proved to be so problematic, Oldham relied on other colonial infrastructures to help him construct his report. The technological networks of the British Raj were the most useful tools to which he had access. The damaged railways, and more importantly the telegraph, helped him assess the lateral movement of the ground and document the supposed electricity generated by the earthquake's aftershocks.[55] However, the networks were more helpful to him once they had been repaired. Their distribution and the ease of communication between them gave Oldham access to the personal observations of hundreds of colonial officials.

The earthquake devastated the imperial infrastructures of communication and transportation in northeast India. The railways and roads were broken and impassable, and the telegraph was useless. The force of the earthquake bent, twisted, snapped, and sunk the railway tracks. It downed bridges, collapsed the stations, and, in some cases, swallowed up whole train cars.[56] Telegraph lines snapped, and roads were fissured, flooded, and broken up. All were unusable, so news initially travelled slowly between Assam and Calcutta. Steamboats, the only transportation system still working, carried the post to and from Assam.

[55] Mallet also used telegraph poles to assess earth movement and intensity. Mallet, *Great Neapolitan Earthquake,* vol. 1, 16, 288.
[56] Memoir, pl. v-xi, xxix, xxvi.

While some of the rail lines were mostly unharmed, others were complete losses. The Therīaghāt line, for example, was permanently closed because it was so badly damaged.[57] The government devoted their resources to getting the trains running again. Most repairs to the tracks were carried out within a month.[58] Although troublesome for the government, the damaged railways were a godsend for Oldham. He used them to study the changes in the landscape and make precise measurements about the permanent lateral movement of the ground. If the land had moved, the tracks made it clear by how much they had shifted. G. E. Grimes, one of the geologists working on the survey explained how he used the mangled tracks to determine the movement:

> Between Daragon and Shaistaganj the embankment, which is quite low, was much broken down and the line twisted into curves for a considerable distance, and as I was going over it on a trolley, Mr. F. P. Anderson, the Executive Engineer, Shaistaganj Section, Assam-Bengal Railway, pointed out to me that the line was shifted several feet from its original positions. As the alignment here was perfectly straight for a considerable distance and part of it had not suffered the slightest, this could be tested with certainty, and at my request Mr. R. K. Coxe, Assistant Engineer, Shaistaganj Section, set up his theodolite and took sights along the line.[59]

Because of its rigidity, the railway had made a permanent and readable record of the seismic movement.

The damage to the telegraph offices was also helpful, but in a different way. They did not track the ground movements, but Oldham recorded examples

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[57] Edward Albert Gait, *A History of Assam* (Calcutta: Thacker, Spink & Co., 1906), 341. As near as I can tell, the line was in Meghalaya at the foot of the East Khasi Hills. *A Handbook for Travellers in India Burma and Ceylon*, (London: John Murray, 1908), 321.
[58] *Report on the Administration*, ix.
[59] Memoir, 297.

of the “Electric Effects” of the earthquake. He believed that the accounts from this earthquake were the most conspicuous of all evidence suggesting that earthquakes changed the electrical state of the “atmosphere and earth currents.”[60] Besides several reports of interrupted communication of telegraph lines, J. G. Morgan, the Assistant Superintendent of Telegraphs in the Shillong subdivision, wrote that while they were digging out the instruments and indicators from the rubble and trying to restore power to the telegraph lines, he, the signalers, and the telegraph master were electrocuted several times, each electrical shock quickly followed by an earthquake aftershock. He also carefully noted that there was no lighting or thunder at the time.[61] Another telegraph master noted that the aftershocks would shut down and then restore the battery currents. He added that several of his officers had been shocked and wires had sparked throughout the region, immediately followed by aftershocks.[62] Oldham did not comment extensively on the implications of these anecdotes but believed that the intensity of the electric shocks meant that the earthquake needed to be explained in more than mechanical terms, and that future seismologists or geologists should explore what electric currents could reveal about the origin of an earthquake.[63]

The time kept by the stations masters at both railways stations and telegraph offices was the most important observation produced by these infrastructures. “Of all the data required in seismological investigations,” Oldham

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[60] Ibid., 190.
[61] Ibid.
[62] Ibid., 191.
[63] Ibid.

wrote, “none are so important and none so difficult to obtain as the exact times at which the various phases of an earthquake were felt.”[64] By comparing times, Oldham would be able to measure the rate the waves traveled, which would help him pinpoint the epicenter and differentiate between different types of waves. He would also be able to analyze how each type of wave traveled through rocks and soils of different types and densities. Mallet, in his chapter in the *Manual of Scientific Enquiry,* included descriptions of how to modify clocks with pendulums to track earthquake time. With some simple alterations to the body of the clock, one could construct a simple instrument that would stop the clock the moment the shock first hit the area.[65] Although the instructions were specifically targeted to members of the British navy, the instructions (and illustrations) were simple enough that anyone could construct this type of seismometer.

On the surface, it seems like the distribution of railway and telegraph offices would be sufficient to make an accurate map of time. Every telegraph office in India and Burma (Myanmar) were required to submit the time they first noticed the earthquake to Oldham. However, he discovered that collecting and making sense of the various time reports was difficult.[66] Most of the difficulties and errors he attributed to the human error and differences between individuals. Two people standing side by side, he suggests, could give two different time reports because one might be able to feel it (or at least recognize it) sooner than the other. Besides that, he discovered that little-used, remote telegraph and

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[64] Ibid., 53.
[65] Herschel, *Manual of Scientific Enquiry*, 218-22.
[66] Memoir, 53-4.

railway stations did not make much effort to keep time meticulously, and in observational seismology, every second matters. The more important stations, such as those in Calcutta, were able to send in accurate times, but many of the Assam stations' numbers disagreed with each other. This, Oldham said, was because "[i]t is not in human nature to take more trouble than is necessary to attain the purpose desired."[67] This human element was what he hoped to eliminate with a network of instruments. If he could get accurate time readings and wave descriptions from only a few key places, then he would be able to construct an accurate report free from human mistakes. Although human error was the primary problem that he identified, the underlying problem of keeping time in the report is the lack of 'civilisation.'[68] Assam was not densely populated and had a very small European population. Because of the lack of British government and citizens, it did not have as many telegraph lines or tracks running through it like other, bigger cities did. Between British constructions was data that Oldham did not know how to read. The remoteness of the earthquake was the problem because, according to the methodology, the closer an earthquake occurs to metropoles, the more visible it becomes.

Oldham's greatest tool was the government's communication systems and the newspapers. Gathering information from several informants, both inside and outside the colonial system made his report possible. Even with a large team and generous funding, conducting a seismological survey was time consuming and

[67] Ibid., 53.
[68] Ibid., 42, 376.

tedious. Oldham had just himself and a team of a few other geologists to survey almost half of the subcontinent. Compounding the problem of space was the urgency to get the survey done as quickly as possible. In Mallet's letter requesting funding from the Royal Society to conduct his Neapolitan Survey, he said that to avoid the earthquake being "lost to Science...the examination must be made with all possible *promptitude*, as every hour alters or removes the characters of the terrible inscription which we are to decipher, and renders circumstantial, local, and oral evidence less trustworthy."[69] The potential loss of evidence, whether through erosion or repairs, was a major problem for Oldham. It was impossible for one person, or even for his small team of geologists, to conduct the survey adequately on their own. They relied on information gathered from people who had lived through the earthquake and who were familiar with the landscape.

Oldham gathered information in India, Myanmar, Bangladesh, and Europe. From south Asia, he needed to know where to find changes in the landscape, the appearance of and intervals between seismic waves, and phenomena that had occurred during or immediately after the earthquake, but that had subsequently subsided or disappeared. All of this information needed to be gathered from local informants. From local populations, he learned both about subtle and major landscape changes. They were able to tell him what small lakes were new, which hillsides had slipped off, and how the elevations of hills had changed. From these testimonies and his own observations, he could analyze how the earthquake left its mark on the surface of the earth, determining where the

[69] Mallet, *Great Neapolitan Earthquake*, ix.

likely epicenter was located. Based on these testimonies, he ordered a resurvey by the Trigonometrical Survey of the area.[70]

Although he initially discredited several observations that showed up in his father's report of the Cachar earthquake which he had labelled "ordinary unscientific descriptions,"[71] he included several similar descriptions and observations in his own report. Most of these letters were from European officials and missionaries, and contained descriptions of the seismic waves, and descriptions of other phenomena, like sand geysers.[72] He never acknowledged that these wave and movement descriptions were helpful, yet they became important later in his career as a seismologist. Although most changes to the landscape could later be verified by observation (many tea plantations were covered in sand), the nature and duration of sand geysers and other phenomena could only be had through written testimonies and letters. In all instances, informers tried to verify their testimony either by describing instrumental changes that backed up their observations, or by providing other peoples' impressions to corroborate their own. Oldham's survey followed the reports he received, in addition to scoping out

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[70] Memoir, 361-69; Davison, *Great Earthquakes.*
[71] Memoir (1883), 89.
[72] Some of these descriptions included "undulatory," "rocking violently" (4), producing a "sensation of seasickness," (5) "it was as if [the ground] was made of soft jelly," (5) "The hill I was on at the time simply felt as if it was being rapidly moved in a horizontal plane backwards and forward." (7) "distinctly horizontal and undulating" (7) "storm-tossed sea" (7) "gyratory motion" (7) "exactly like rollers on the sea coast," (20) "the earth swayed like a cradle with all the contents on it" (21) "The earth resembled waves coming from opposite directions and meeting in a great heap and then falling back" (26) "the first thing I noticed was a wave-like motion passing under my feet, something like the swing of a suspension bridge" (29).

places he thought might yield information. Mostly, however, he followed up the informants' proof in an effort to verify. In other words, Oldham's report was largely directed by the reports of the public.

Oldham also corresponded with observers in Europe. He includes most of the information from this correspondence in his last chapter "The Unfelt Earthquake," which Charles Davison retroactively labelled the most important chapter because of its use of instruments.[73] In this section, he recorded the way various instruments across Europe reacted to the Assam earthquake. He labeled these unfelt but recorded waves "cryptoseismic" waves.[74] He noted the time and impact on every instrument from pendula to springs. Using the data gathered from Europe, he noted how earthquake waves travel through the earth's interior. He hoped that this would tell him something about the structure of the interior of the earth, as well as its inner mechanics. Oldham's last chapter showed geophysics' potential for having a worldwide network of instruments and observers.

Both the newspapers and the telegraph were imperative for requesting and collecting information. Besides personal letters, government correspondence, and official reports, most discussion of the earthquake took place in the newspapers, both those printed in India and abroad. The public used the newspaper to read about a disaster, but also to verify their own impressions. By corroborating their story with others, they crafted a narrative of the earthquake that was published in newspapers both in India and in Britain. Other newspapers picked up the story

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[73] Charles Davison, "Richard Dixon Oldham," 112.
[74] Memoir, 227.

too, including papers in the United States.[75] Although Oldham pulled a lot of his information from newspapers, he did not trust this public-crafted narrative. He believed that the crowd, instead of creating an accurate report through corroboration, created a narrative that maybe agreed with others, but not with reality.[76] Crowdsourced knowledge in a colony, he believed, was inherently inaccurate. Despite his frustration with the newspaper narrative, Oldham still sourced several reports from them and used them as a way to send his circulars to the public, asking them to answer a set of questions about the quake. The telegraph was also key. He used this to request information from people working within the colonial system. One of the decisions he had to make in the colonial setting was how to deal with Indian testimonies.

The Indian Voice

Seismologists had to address the inclusion of human, and more specifically Indian, observations in their reports. Part of calibrating seismology outside of Europe was deciding how to deal with public observations, an essential part of observational seismology. Seismologists had to decide how much trust to place in such observers and decide how scientific and objective they could expect the public to be. To understand how scientists worked with Indians to create the

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[75] Both the *New York Times* and the *Los Angeles Times* covered the earthquake story. "The Indian Shakes. Appalling Ruin in the Province of Assam – Renewals," *Los Angeles Times* (Los Angeles), June 19, 1897. https://search.proquest.com/docview/163833536/615EF02E4FF94E14PQ/33?accountid=12964; "India's Severe Earthquake," *New York Times* (New York), June 15, 1897. https://search.proquest.com/docview/95453073/615EF02E4FF94E14PQ/36?accountid=12964.

[76] Ibid., 40, 53-54.

earthquake report, it is necessary to analyze the paradoxical position of the Indian voice in the report. British geologists and informants could not have completed the report without gathering observations from Indians, but they also actively worked to silence or control the Indian voice throughout the report. They included information gathered from Indians while simultaneously undermining the credibility of Indians themselves. This resulted in some adjustments unique to the seismological methods and report in India, including most notably an almost obsessive focus on verifying information.

In several of the narratives R. D. Oldham collected about the 1897 earthquake, the reporters noted the fearful reaction of the Indians. In these letters, their fearful cries are reduced to a general, panicked, Indian voice. This is the reaction expected by the British of the Indians. It was (from their perspective) religious, panicked, and unreasonable, not suitable evidence to include in a report "from a scientific point of view alone."[77] Oldham, and the reporters he read, did not consider the Indian voice able to provide an accurate assessment of a natural disaster, so it could not be used as an index of the earthquake's severity. The newspapers published several stories of the inability of dark-skinned people to cope with, let alone scientifically observe, an earthquake. One striking anecdote about an earthquake that occurred in 1762 describes how fear damaged or even killed some people:

> The native account says that the earthquake began at Chittagong with a gentle motion which 'increased to so violent a degree, for about two minutes, that the tree, hills and houses shook so severely that it was with difficulty many could keep their feet, and some of the black people were

[77] Ibid., 2.

> thrown to the ground, whose fears operated so powerfully that they died on the spot; others, again, were so greatly affected that they have not recovered themselves since.[78]

Although this account describes an earthquake that had happened more than 100 years before, they proceeded to compare the effects of the earthquake to the 1897 disaster: "It cannot escape the reader's notice how precisely similar in their effects that and the late earthquake appear to have been."[79] Fear could kill the 'sensitive' Indians. This sensitivity seemed to work only one way, however. The Indians, according to the British imagination, could not harness their sensitivity to become expert earthquake observers, better than any European. The earthquake simply made them too fearful and irrational to objectively observe it.

Living in an earthquake prone area, Europeans believed, was one reason that the Indians could not be trusted to observe their own earthquakes. According to nineteenth-century speculation, people living in seismic areas were prone to all sorts of moral, mental, and physical failings. In humans, earthquakes created a "state of mind [that] becomes unfavourable for the maintenance of a high civilization. The best conditions of the state can only be secured when the laborer toils with the assurance that his work will endure long after his own brief life is over."[80] As "natural terrorisms," earthquakes generated both intense and constant anxiety as well as apathy about the future.[81] Milne devoted a section of his

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[78] *The Earthquake in Bengal and Assam: Reprinted from the "Englishman,"* (Calcutta: "Englishman" Press, 1897), 21-22. This booklet containing several anecdotes from the newspapers was intended for the English public in India.
[79] Ibid., 22.
[80] Coen, *Earthquake Observers,* 187-88.
[81] John Milne, *Seismology with Fifty-Two Figures,* 2nd ed (London: Kegan Paul, Trench, Trübner, & Co., 1908), 229.

introductory book on seismology to explaining the effects of seismic activities on "morals and mentalities:"

> A disastrous shock will throw the weaker members of a community into a state of terror or hysterics, and at every little shock, perhaps, for the remainder of their lives they will either be so far unnerved that the do not move, or else, seized with alarm, they will seek a place of safety. I am acquainted with two cases which, in consequence of the nervous excitement produced by comparatively small disturbances, terminated fatally…[with the regular occurrence of earthquakes] it would seem natural that ideas of permanency would be destroyed, a carelessness for the future might be engendered, and timidity might be established amongst the weaker members of a community which would handicap them in the struggle for existence. The general temperament of a nation is no doubt largely due to its environment, and it is not unreasonable to suppose that serenity of demeanour and carelessness of the future may hold some relationship to repeated exhibitions of seismic and volcanic energy.[82]

Milne wrote that earthquakes did not affect every race in the same way. Europeans were prone to mental weaknesses, such as loss of nerves and hysteria, while the Japanese were susceptible to physical consequences like tetanus and complications of the spine.[83] The effects on Indians were supposedly mainly mental, and their resulting actions differed widely, with the extremes being either panicking themselves to death (as the 1762 anecdote describes) or continuing with their work as if nothing had happened.[84] At no point on this scale of reactions would Indians qualify as competent and trustworthy observers.

The documentation of Indian reactions appears in nearly every letter included in the report. The Assam plains people, in "horrified alarm," fled to the

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[82] Ibid., 229-30.
[83] Ibid., 230. Milne based his comments on the work of Julius Scriba (1848-1905), a German doctor who taught Western medicine in Japan.
[84] Memoir, 17.

hills.[85] The Garos, living near the epicenter of the earthquake, "were thrown into a state of stolid bewilderment."[86] The villagers "were panic-stricken,"[87] seemed "most helpless,"[88] and of those that fled towards Lakhipur and found the way flooded, "the poor creatures got more alarmed than ever."[89] Aftershocks evoked "a wail of human voices."[90] Although not helpful as evidence that would be used in categorizing the earthquake's severity, these accounts served important functions in the narratives. The European reporters defined themselves in opposition to this oriental voice, setting boundaries between the observer and the observed. By observing the Indians' reactions as part of the effects of the earthquake, they depicted themselves as the calm, rational observers, and the Indians as the chaotic objects of observation. The Indians were positioned as a part of nature, a part of the effects of the earthquake, but not the observers. As Kama Maclean argued in her chapter *The Art of Panicking Quietly,* "[i]n India, the maintenance of a certain mien that performed notions of authority and dominance became a management strategy and a method of containing anxieties and fears attended by imperialism."[91] Maintaining a calm disposition, especially in the face of colonial panic, was an important duty for a Briton. The colonial

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[85] Ibid., 14, 27.
[86] Ibid., 14.
[87] Ibid., 15.
[88] Ibid., 18.
[89] Ibid., 16.
[90] Ibid., 17.
[91] Kama Maclean, "The Art of Panicking Quietly: British Expatriate Responses to 'Terrorist Outrages' in India, 1912-33," in *Anxieties, Fear and Panic in Colonial Settings: Empires on the Verge of a Nervous Breakdown,* ed. Harald Fischer-Tiné (Cham, Switzerland: Palgrave Macmillan, 2016), 156.

order, they seemed to feel, rested on their ability to remain calm in emergency situations.

The same standards did not apply to Europe. Human reaction was embedded in the scale used to ascertain earthquake intensity and was an acceptable and important part of any earthquake report. Letters written to seismologists included even the subtlest and seemingly unimportant details, such as the falling over of a toy soldier.[92] Women's reactions were considered particularly useful, since women were supposed to be more sensitive than men.[93] The Rossi-Forel Scale assumed a standard human reaction to earthquakes of varying severity. For example, "general awakening" and "startled persons leave their dwellings" were parts of a level 5 earthquake, and "general panic" was an important effect of a level 7 earthquake.[94] The same standards, in Oldham's opinion, could not be applied to Indian bodies or responses. In the human element of his scale, earthquakes are merely 'noticed' by increasingly large amounts of people.[95] Because of the general distrust of Indian reactions, Oldham made them unimportant with his scale.

Thomas Oldham, in his record of the Cachar earthquake, also hints at another reason why he found the Indian voice untrustworthy. After the 1869 shock, the Indians carried on with what they were doing or quickly resumed activities. This was not helpful for seismological research because observational

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[92] Coen, *Earthquake Observers*, 87.
[93] Ibid., 3, 86, 87, 93, 128, 139, 198.
[94] Charles Davison, *The Founders of Seismology*, (London: Cambridge University Press, 1927), 103.
[95] Ibid., 140.

seismology is based on the observations of the effects caused by an earthquake; something that did not 'record' an earthquake, then, was useless. Once the danger was over, the Indians voice was no longer a useful recorder of the shock. In Thomas Oldham's notes, after "…violently gasping out their short exclamations of entreaty or worship," the Indians "quieted down to their wonted occupations *as if nothing had happened* [emphasis added]."[96] A cook, during the 1897 earthquake, also did not 'register' the earthquake.

> …it was amusing to find my cook busy at work preparing dinner within half an hour of the occurrence. There he was, as though nothing had occurred, on the plinth of a burnt down hut only just above the water and surrounded on all sides by it. I was very grateful to him later on for not having parted with his wits.[97]

Although Surgeon-Major E. F. H. Dobson praises his cook's calm reaction in his letter, he is also noticing that his cook had not registered the earthquake in any recordable way; the cook had not adjusted his behavior even though he had experienced one of the strongest earthquakes on record. This non-reaction echoes the geologist's frustration with Indian architecture that did not record the quake in a way that the British would recognize.

"Ignorant and illiterate tribes," as R. D. Oldham termed them, were also a problem.[98] Of the areas of land that were affected by the Assam Earthquake, Oldham could only survey approximately one-third of it. One-third could be surveyed, one-third was where the 'ignorant and illiterate' tribes lived, and one-third could not be surveyed, whether that was because it was in dangerous terrain,

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[96] Memoir (1883), 1. This also hints at an Indian primitiveness.
[97] Memoir, 17.
[98] Ibid., 49.

such as the Himalayan mountains, or because it lay outside of Britain's political boundaries. Because of the communication and education barrier, Oldham decided that it would not be worth the time to question the tribes. There were, he said,

> …but few and widely separated centres from which an intelligent account could be hoped for…any attempt to have obtained this information would undoubtedly have occupied much time, besides being almost foredoomed to failure, so the attempt was deliberately abandoned in order that attention might be given to those points with regard to which this earthquake seemed likely to add to our knowledge.[99]

He excused himself by emphasizing the incommensurability of their language and ability to give scientific, objective, and accurate accounts of the earthquake. Native knowledge, he implied, could add nothing valuable to the British or European theories about earthquakes. Their experience, including any deaths outside of the cities, went unrecorded, silenced by Oldham's report. His statement about their ignorance is ironic, especially considering his dependence on local knowledge to complete the earthquake report.

Several chapters in the report explain in detail the changes to the landscape of the Garo Hills and surrounding areas, changes he relied on locals to observe and describe, although he rarely mentions it. For example, he found a pool that he believed had not been there before. "In reply to an enquiry of my guide I was informed that there was no pool here before the earthquake."[100] The order is important here; Oldham first emphasizes that he noticed the unique nature of the pool, inferred it was caused by the earthquake, and then verified his

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[99] Ibid., 29, 49.
[100] Ibid., 157

conclusion with his guide. In reality, however, the order was usually switched. Oldham relied on local knowledge of changes that he later verified. The Garos and Khasis informed him of changes, then he would investigate and verify their claims. There were only a few new formations that would have been obvious to Oldham, such as fissures. Otherwise, local knowledge was all he had to begin investigating. He also hints at the importance of local knowledge when he discusses the "ignorant and illiterate tribes." Part of the problem was that these areas were "sparsely inhabited."[101] Without several informers, Oldham did not know where to begin. The landscape itself did not lend itself to easy observation. It was covered in thick bamboo forests and jungles. Oldham notes that the rate of travel in the jungles, once one left the path, was about one-third of a mile per hour.[102] This made simply happening upon a new geological change caused by the earthquake highly unlikely. The impenetrability of the landscape meant that he had to work closely with Indian locals, who could identify recent changes because of their familiarity with the topography. The existence of this close partnership is suppressed in the report and must be inferred from Oldham's occasional revealing statements.

Not all the local knowledge was based on noticing the specific geological differences. Sometimes the changes were inferred because of other landscape changes. The local communities had their own methods of reading the landscape to detect subtle and sudden changes. They taught these methods to Oldham, who

[101] Ibid., 49.
[102] Ibid., 129.

appropriated them as proofs in his report. One example is bamboo. Bamboo is sensitive to sudden changes in water and soil and will die if the changes are too drastic. When the earthquake struck, some bamboo was killed in clumps, indicating that a change had taken place. The Indians pointed this out to Oldham as proof of what they observed. Oldham took this knowledge about bamboo and turned it into a seismological index unique to India.[103] Although it had foiled him in his attempts at reading architectural damage in India, bamboo became an important index, verifying landscape changes.

Even though he rarely acknowledged the Indian knowledge, he was always careful to verify their claims. He understood that others would recognize where he got his information, and a report based on Indian knowledge was not much better than nothing. Thomas Oldham spent most of the first half of his career verifying geological information gathered by army surgeons, who gathered most of their information from Indians. He specifically tried to remove the Indian knowledge element from these reports and systematize them; it was only later, after Oldham had verified all of the information with European geologists that the GSI became a premier and globally relevant scientific institution.[104] Later, R. D. Oldham was careful to verify all of the Indian information, aware that if the report was going to be accepted as an important document of an earthquake by the entire scientific community, dependence on Indian knowledge was not enough. By masking the origins of the knowledge and only including the instances that he

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[103] Ibid., 140, 153-4.
[104] See Kumar, "Economic Compulsions," and Deepak Kumar, *Science and the Raj, 1857-1905* (Delhi: Oxford University Press, 1995.)

could verify, R. D. Oldham undermined and quieted the critically important Indian knowledge contained in his book; without it, his report would not have been the landmark report it turned out to be.

But verifying the reports was only necessary when they were given by Indians. Oldham accepted reports from the Welsh Baptist missionaries, who were also living near the Garos, as true. Although he also included proof of their information, the proof was provided by the missionaries, and was presented in a different order. Mr. and Mrs. Evans, the missionaries, informed Oldham that new stretches of the road could be seen after the earthquake that they could not see before, meaning that the altitude of the hills had changed. Oldham presented this information first as fact. It was only after that he informed readers that the Evans had verified their observations with a test.

> …a few days after the great earthquake Mr. Evans took a piece of board and nailed it to a stout post in such a position that its upper edge was sighted on to the crest of a ridge about one and a half mile to the west. When I saw it, at the end of December, six months after the earthquake, the top edge of the board no longer pointed to the crest of this ridge, but to some way down its slope…These tracts are of interest as suggesting that no inconsiderable fraction of the total movements which have taken place, were accompaniments of the large number of severe aftershocks.[105]

Oldham accepted the Evans's information as true; the Indian guides and informers did not get the same amount of trust. He did act based on both the Indians' and missionaries' observation however. Because of their reports, Oldham decided that the landscape had changed enough that resurveying was necessary. He reordered a Trigonometrical Survey of the area, although it was not carried out very well.[106]

[105] Memoir, 157-8.
[106] See Davison, *Great Earthquakes.*

One of Oldham's most important observational tools was the imperial network of communication. With railway and telegraph stations across the subcontinent, he could request information about how strongly the earthquake was felt at each location, the time it was felt, and proof to verify the statement. The empire employed several Indians at these centers, so Oldham worked with both European and Indian reporters within the colonial system. In the appendix of his report, he includes reports collected from these stations. He sent circulars, via the press and telegraph network, and requested letters from officers working for the government. The language of the circulars was prescriptive. One circular he sent required information about: "(a) Extent of fissuring (b) Outpouring of sand and water (c) Filling up of river channels (d) Opening out of new *khals*."[107] These circulars required specific, regulated responses, most of which Oldham used in his report. Because they were so prescriptive, he believed he had eliminated the human bias, or enough of it that he did not have to worry about inaccuracies sneaking in. These reports were essential for timing the earthquakes. Because the stations needed to have clocks, most reporters were able to give a fairly accurate time the earthquake was felt. The Calcutta telegraph office transmitted the time to other telegraph stations every morning, daily calibrating the time across the subcontinent. Ideally, government officers adjusted their own timepieces to match the telegraph station's clock, but Oldham discovered that at distant outposts, these careful calibrations were often ignored. This proximity to technology also lead the reports another step away from the human element of seismology towards a more

[107] Memoir, 343.

instrumental and global science. The best reports described when and how the observer checked his watch, and how accurate the watch was. For example, “as we got up [from being knocked over by the earthquake] I looked at my watch and noted the time 5 hours 6-7 minutes P.M. Calcutta time.”[108] Even if the time could not be determined, the informers wrote it:

> There being no telegraph wire to Tura, there is no means of checking our local time. We depend chiefly on a sundial, but as it was inaccurately put up, the result is unreliable.”[109]

Oldham depended on the daily time calibrations across the subcontinent to measure the rate the earthquake waves traveled, and for how long they lasted. The colonial networks functioned not only as a network of earthquake observers, but also as a network of instrument observers. Because the language of the circulars was prescriptive, Oldham did not discriminate between reports from Indian officials and those from British officials. As long as the Indian voice was regulated by British systems and networks, it was an acceptable form of scientific proof.

Uncharacteristically, Oldham includes a letter written by Babu Hiranmoy Mukerji, who was probably a wealthy Indian from Muktagacha in Bangladesh. Mukerji submitted a letter reporting the earthquake, sent soil samples, identified the cause of the earthquake, and suggested measures the government could take to prevent further catastrophe. Mukerji pointed out that because the wealthy live in stone or brick-built houses, and own plantations, they have suffered the most.[110]

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[108] Ibid., 20.
[109] Ibid., 9.
[110] Ibid., 23.

He suggests two principle causes for the earthquake. The first is natural, the second moral.

> The earthquake is commonly calculated by the Hindus according to a formula quoted below:-
> ‘If you get famine, drought and plague in one and the same year, you get the earthquake that year.’
> This calculation has indeed been verified.[111]

The second cause was a lapse in morality. A supernatural agency is “put into action by the vice or virtue of mankind.”[112] Mukerji suggests that the British law of religious toleration has allowed people not to follow their religion carefully. He asserts that “any man in any community should not be allowed to violate with impunity the ordinances of the religion which has been accepted by that community.”[113] He argues that coercing people to align their actions with their community’s religious practices (although they were free to convert to other religions) would prevent future earthquakes.

Oldham may have included this letter, as he hints, out of respect and duty, but he did not include it because it provided critical scientific observations. This is the only time he includes an unmoderated, unmodified, and unverified Indian letter. Perhaps he did this because of its religious nature. Left on their own, it seems to imply, Indians can try to replicate Western science, and even provide some useful details and data, but ultimately, they draw the wrong scientific conclusions, conflate natural and supernatural causes, and suggest archaic and ineffective solutions that contradict the supposed modernity the British Empire

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[111] Ibid., 24.
[112] Ibid.
[113] Ibid.

was trying to implement. He introduces Mukerji as part of an "important section of our fellow subjects," but not part of the knowledge building community.[114] Mukerji is little more than an informant from Bangladesh. Where the Indian voice was most obvious in the earthquake report, it is not included as a serious, but as a "dutiful" addition; it promotes the idea of the apparently fundamental unscientific nature of Indian observations.

Gyan Prakash, in his book *Another Reason,* suggests a reason for this in his discussion about museums in India. He argues that the British faced a dilemma when bringing and exhibiting their science to India. They wanted the Indians to recognize the authority of Western knowledge, but they were also reluctant "to acknowledge them as knowing subjects," which resulted in the British having "to regard Indians as always less than adequate, always lacking some key attribute. This justified colonial dominance, but it also conceded that the colonial project would never achieve complete success, that Indians would remain unconquerable in the last instance."[115] The inclusion of this letter, then, may have partially been to justify Oldham's control of the Indian voice and to imply to other European seismologists the specific difficulties of conducting observational seismology in India. European seismologists relied heavily on reports, respecting the public observers' contributions as valuable and necessary components of doing science.

From the exclusively imperial point of view, Indians were not active, questioning participants in creating and contesting knowledge. They were, in the

[114] Ibid., 21.
[115] Gyan Prakash, *Another Reason: Science and the Imaginations of Modern India* (Princeton: Princeton University Press, 1999), 48.

report and letters, little more than uneducated informants, simply providing the requested information with no speculation about its meaning. Looking outside of the British network gives us a very different understanding of how Indians understood and participated in earthquake observation. Admittedly, the instances of Indians commenting on the 1897 earthquake outside of the government network are difficult to find, but some examples appear in nationalist newspapers. Indians weighed in on the science of the earthquake outside of the constraints of imperial surveys. One example is a letter to the editor of the *Amrita Bazar Patrika* by Jagadananda Roy (1869-1933), a science writer, teacher, and science fiction author. He wrote a short, poignant, and insightful piece critiquing a previous contributor's conclusion.[116] He believed that because of the nature of waves, the other informant, identified as "Dwfdt," had drawn the wrong conclusion while watching a wall sway in Krishnagar. Roy's letter to the editor shows that many Indians did have a working knowledge of seismological theories. His letter challenges the image of Indians as scientifically incapable since he critiques conclusions based on his own careful observations and a solid understanding of earthquake waves. This differs sharply from the image of Indians' inferior scientific ability Oldham was trying to create. Obviously, it did not accurately reflect the knowledge that many Indians had about the earthquake or their 'ability'

[116] "Jagadananda Roy (1869-1933)," Visva-Bharati: A Central University and an Institution of National Importance, accessed February 20, 2018, http://www.visvabharati.ac.in/JagadanandaRoy.html; Jagadananda Roy, "Wall-Rocking Phenomonon at Krishnagar," *The Amrita Bazar Patrika* (Calcutta) July 24, 1897, 6.

to contribute and critique science in a meaningful way. This was not a nation devoid of competent and capable observers by European standards.

The answers to the questions of how to include Indian observations depended heavily on ideas about race and the power structure of empire. It is also important to consider the international reputation of a scientist. Could trusting observers too much jeopardize the international significance and credibility of a scientific report, and through the report, the scientist himself? Oldham seemed to think so. In several of his works, Oldham critiqued the use of human observations. For example, he condescendingly suggested that the increasing number of earthquake reports in newspapers was a phenomenon that should be studied by a psychologist rather than a seismologist, as the increasing attention to earthquakes was not a result of increasingly frequent earth tremors.[117] He identified the divide between geology and geography, which was "determined by absence or existence of human records" as "illogical and unworkable, or, in a word, unscientific."[118] Geographers, because of their dependence on human records, were less scientific than those who did not define their limits according to human records. According to Oldham, any science based on human observation was by nature unscientific. He, however, was still dependent on human observations. This required him to engage in a careful balancing act of building an internationally credible scientific

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[117] R. D. Oldham, "Recent Earthquakes," *The Geographical Journal* 33, no. 3 (1909): 295-96.
[118] R. D. Oldham, "A New Geography," *The Geographical Journal* 34, no. 2 (1909): 157.

report while simultaneously undermining the data he used, pointing out how his report was scientific despite its use of observations.

Other Institutions

Other institutions, such as the tea plantations, exacerbated the effects of the earthquake. Although they did not feature prominently in Oldham's report, they provide further proof that the British empire in Assam increased the destructive potential of the earthquake. Oldham noted many of these effects but did not know how to read them as indices, so they remained simple observations. When confronted with phenomena that did not fit his methodology or his mathematical formulae, Oldham was reduced to the role of informant in his own report. For the sake of thoroughness, he included them but did not have the tools or epistemology to interpret them.

Since the 1840s, the British had been removing trees from the lowlands near the Brahmaputra River and cultivating tea.[119] The trees were used for railway ties, and the cleared area was repurposed for growing crops. Although the empire did take measures to make the timber market sustainable in Assam, their efforts were not very effective.[120] "Tens of thousands of acres of jungle and wasteland were converted into private estates, inhabited by labourers, Indian clerical staff,

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[119] *Report on the Administration*, 81, 82; Gait, *A history of Assam*, 348-9; See, *Assam: Sketch of its History, Soil, and Productions; with the Discovery of The Tea-Plant and of the Countries Adjoining Assam. With Maps* (London: Smith, Elder, and Co., 1839.) https://hdl.handle.net/2027/umn.31951002324130v.

[120] *Report on the Administration*, 84. *Statement Exhibiting the Moral and Material Progress and Condition of India during the Year 1901-1902, and the Nine Preceding Years* (London: Eyre and Spottiswoode, 1903), 108-09. https://books.google.com/books?id=PfU2AQAAMAAJ&printsec=frontcover#v=onepage&q&f=false.

and European managers and their assistants."[121] In addition to deforestation, the British increased the population density of the area by importing labor to work the plantations. Originally, the Assam lowlands were sparsely populated, the majority of the population living in the hills. The local population had little interest in working on the plantations, so the owners were forced to outsource the labor, shipping in people from across India and Bangladesh.

Keeping the labor force in Assam was one of the most difficult tasks of the plantations managers and supervisors. With the appalling working conditions, high mortality rate, and a below subsistence wage that was almost never paid in full, many Indians who worked on the plantations tried to escape. The plantations managers resorted to extra-legal coercion to keep the Indians on the plantations, including flogging and imprisonment if caught trying to run away.[122] By the 1940s, Assam had a population of more than three-quarters of a million, and the tea plantations employed more than 60% percent of them. The tea industry in Assam was one of the few industries in its more than 100-year history that "never suffered from a complete stoppage of production during its long history."[123] The earthquake triggered flooding in the lowlands and fissures that erupted sand. The sand and water destroyed many of the tea plants and made several acres of land uncultivable. But overall, the earthquake did not do much to stop tea production. The output had a couple bad years, but it had increased its output by more than

[121] Rana P. Behal, "Power Structure, Discipline, and Labour in Assam Tea Plantations under Colonial Rule," *International Review of Social History* 51, supplement 14 (2006): 159.
[122] Ibid.,156-58, 163, 170.
[123] Ibid., 143-44.

250% between 1885 and 1901, increasing from 53.5 million pounds of tea exported to 134 million pounds.[124]

Recent studies have documented the connection between deforestation and earthquake devastation, including the increasing likelihood and extent of landslides and rockfall during and immediately following an earthquake.[125] The Indian and Bangladeshi who worked on the tea plantations were the ones who suffered the most. In Sylhet, several people drowned or were buried under mud and sand when the riverbank gave way.[126] The Administration report estimated about 545 people dying because of the collapse.[127] The deforested soil in the lowlands became unstable as a result of the earthquake, causing liquefaction and extensive fissuring. The loose riverbank subsided, leading to extensive flooding as well. Although it is unclear the extent to which deforestation contributed to the tragic situations in the lowlands, it is reasonable to say that it did have some effect. By increasing the population density in that area and destabilizing the soil, the British empire probably increased the danger of the earthquake.

Damage to food and water supply infrastructures also caused problems for the population. Damage to the water reservoirs and drainage exacerbated or

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[124] Gait, *A history of Assam,* 350; *Report on the Administration,* ii.
[125] K. Sudmeier-Rieux, M. A. Jaboyedoff, Breguet, & J. Dubois, (2011). "The 2005 Pakistan earthquake revisited: Methods for integrated landslide assessment," *Mountain Research and Development, 31*(2), 112-121. http://dx.doi.org.ezproxy.lib.ou.edu/10.1659/MRD-JOURNAL-D-10-00110.1 Retrieved from https://search-proquest-com.ezproxy.lib.ou.edu/docview/899143760?accountid=12964; http://sites.dartmouth.edu/NepalQuake-CaseStudies/deforestation/.
[126] Gait, *A history of Assam,* 345.
[127] *Report on the Administration*, ii.

resulted in an outbreak of cholera in the Brahmaputra Valley, as well as "an epidemic fever which caried off 79,524 persons in Cachar and Sylhet, [which was] more than double the mortality from this cause in 1896."[128] Some food stocks were destroyed, but "it was much less than was at first feared would be the case."[129] The surviving harvest was good, so anyone that could work on food production (in the Administration's words, "willing to work"[130]) had enough food. Consequently, the province decided that it would devote its funds to repairing colonial infrastructures rather than giving money to relief.[131] Although they listed "hous[ing] the houseless" and "feed[ing] the people" as their two most urgent priorities, it was their third and final priority, "re-open[ing] communications" that received the most funds.[132] The administration hoped that with this redistribution of funds, the public works would be repaired within three years.[133] Because of the failed supplies, disease devastated the valley, and the reassignment of relief funds from the population to infrastructures the empire exacerbated the problem.

Besides deforestation, the railway directly affected the landscape and made the earthquake visible. Oldham noticed that the earth had fissured parallel to train tracks and roads. He noted that,

> …the heaping up of an embankment on the surface of the alluvium produces a line of weakness along its base on either side. Besides this cause of weakness, we have the fact that the material for the embankment is usually derived from a row of borrow-pits on either side of the bank.

[128] Ibid., iv.
[129] Ibid., ii.
[130] Ibid.
[131] Ibid. "Contrary to all expectations, therefore, there was little or no scope for charitable relief or relief works."
[132] Ibid.
[133] Ibid.

> These two causes acting together give rise to a special aptitude for fracture, and we find nearly everywhere throughout northern Bengal and lower Assam that the roads and railway lines were bounded on either side by a set of fissures running parallel to the road in all such places where fractures have not, for other reasons, been formed across the road.[134]

The colonial altering of the landscape fissured the ground. The British broke their own empire.

All of these effects, although they showed the damaged caused by imperialism and its technologies and infrastructures, did not fit neatly into observational methodology. Oldham did not know how to read them as indices of the earthquake.

Conclusion

The modifications to observational seismology suggested by Oldham resulted in a type of colonial seismology. There were several elements that stayed the same, such the reliance on communication systems and observing Western technology and buildings. This adherence meant that Oldham was mostly limited to observing the damage to the empire, rather than analyzing the earthquake as a disaster for everyone in northeast India. But he also changed the methodology to fit the local situation. The modifications were driven much more by social than physical reasons. Maintaining the hierarchy of power accounts for many of the differences between colonial and European observational seismology. First, Oldham changed the scale. This was not uncommon, as several geologists modified the Rossi-Forel scale.[135] However, although Oldham used the lack of

[134] Memoir, 90.
[135] Roger M W Musson, Gottfried Grünthal, and Max Stucchi, “The comparison of macroseismic intensity scales,” in *Journal of Seismology*, (2010): 414.

brick and stone buildings as the primary reason for changing the scale, the most important change was the elimination of human reaction, merely including whether anyone had felt the earthquake. This meant that Indian reaction could not be used as an official index of the earthquake's intensity. European seismologists, on the other hand, depended on this human element, valuing even the smallest details of how an earthquake affected the body. Although they could not be officially used, the report turns the Indian, and especially the Indian crowd, into an object of observation. The Indians themselves were not valued as observers and informers unless they were working within the colonial system.

The Indians, however, found their own proofs of how the earthquake changed the landscape and passed this knowledge on to Oldham, who disguised its origins and presented it as a purely rational way to observe an earthquake. Indigenous methods became an important part of colonial seismology. Along with the inclusion of indigenous knowledge came an almost obsessive need to verify Indian observations. Unlike European observations, Oldham framed Indian observations as secondary corroboration to his own primary observations. The trust and respect between seismologist and public observer was absent in India if the observer was an Indian; in Europe, this trust and communication was essential for doing seismology. Although Oldham's report is "one of the most careful and detailed [observational seismology reports] that we possess,"[136] its unique methodology meant that the effects of the earthquake on the local indigenous population and their contributions to his report were downplayed to the point of

[136] Davison, *Great Earthquakes*, 139.

being almost invisible. Ironically, the interior of the earth and its mechanics, something that Oldham would never actually see, became more visible than the people who he talked with and learned from.

Chapter 3: Oldham and the 'New Seismology'

The 1897 earthquake was a moment in seismology where the British and the Indians had an opportunity to collaboratively build a new type of methodology. Instead, Oldham believed that the better option would be to use the earthquake survey as an argument for moving seismology in an instrumental, and thus geophysical, direction. This, he believed, would allow seismologists across the globe to work on earthquake data simultaneously, provide data for answering fundamental questions of geophysics, allow seismology to transcend place, lessen seismologists' dependence on public collaboration, measure more than the earth's crust, and make collecting earthquake data from across the globe quicker and easier. The instrumental seismology that resulted replicated many of the colonial practices embedded in his report, including the invisibility of Indian informants, the missed opportunity to use local knowledge to mitigate earthquake devastation, and the loss of collaboration between the public and scientists. When compared with the situation in Japan, where Milne and Ōmori used instruments but also focused on collaboration and the practical uses of seismological knowledge, the difference is striking.

Oldham's earthquake report was an argument for what he thought seismology needed to be a science of. In his mind, the differences (with the European experience) of doing seismology in a colony was an impediment rather than an opportunity. No matter how 'civilized,' colonies were not conducive to conducting seismology, and especially observational seismology. He showed that unless colonies had European structures and infrastructures, seismologists could not conduct observational seismological surveys, which limited them to their heavily ‘developed’ colonies. Earthquake reports needed to be written in spite of colonial circumstances. Oldham made it clear that collecting information from Indian informants was at best inconclusive and at worst untrustworthy. The best way to solve these problems, he argued, was to install seismographs at key points on the subcontinent. Removing everything that made the Indian earthquake ‘Indian’ would, he believed, make seismology more objective and intellectually pure. Doing macro-seismology in a colony required researchers, according to Oldham, to strip seismology’s tools and methods down to the skeletal basics. Observational seismology could not keep up with the increasingly sophisticated new science, and colonialism only exacerbated the problem. Because of the discrepancies in architecture, infrastructure, language, communication systems, and supposed human reactions, colonial surveys were more difficult and less informative.

He argued that instruments, imperfect as they were at this point, were better for seismology than fieldwork observations. Instruments allowed seismologists to record precise measurements and times. Further, the conclusions that seismologists could draw from instrumental data gave evidence of the interior workings and composition of the earth. It did not matter so much that the instruments themselves were not perfect, or that some instruments that were used as seismographs were not even designed for that purpose. His report and later work on the earth’s core and seismic waves demonstrated that instruments were good enough to justify the switch from observational seismology to the ‘new’ seismology, as his contemporaries termed it.[137] But seismographs came with a new set of epistemological and technical questions and problems. Seismologists were experimenting with and inventing several types of instruments, trying to determine what a good seismograph measured and what constituted an accurate seismogram. Instrumental seismology traded perceived human error for instrumental error, privileging instrumental inscriptions above human experience.

Oldham did not invent the dichotomy between observational and instrumental seismology. As Oldham was tramping around the Garo Hills collecting data, seismology was in a state of flux. Scientists were debating whether seismological observations primarily needed to be gathered in the field or in the observatory, whether seismology was more of a geophysical or geographical science, what role instruments should have in observations, and whether seismology should be a purely intellectual or a heavily applied science. Oldham's report was his response to this debate from a colonial seismologist's point of view. The intricate differences of doing seismology in colonies was an important point of consideration for seismologists trying to determine what type

[137] Clarence Edward Dutton, *Earthquakes in the Light of the New Seismology* (New York: G. P. Putnam's Sons, 1904.) https://hdl.handle.net/2027/nyp.33433090751540; G. K. Gilbert, "The New Seismology." *Science* 20, no. 520 (1904): 837-838. http://www.jstor.org/stable/1630325; John Milne, "The New Seismology." *Nature* 91, no. 2269 (1913): 190-191; Hiram W. Hixon, "Earthquakes in Light of the New Seismology." *Journal of the Franklin Institute* 168, no. 3 (1909): 227-234. https://www.sciencedirect.com/science/article/pii/S0016003209901430?via%3Dihub; "Earthquakes and the New Seismology." *The Living Age.* (Boston), June 24, 1905. https://search.proquest.com/docview/90219783?accountid=12964%0A.

of science seismology was. As Coen says, “imperialism motivated and structured internationalism in seismology.”[138]

Collecting data from around the world allowed seismologists to see how seismic waves propagated through different types of materials on the surface. From this, they could begin to guess about the material construction of the interior of the earth. As Oldham showed, if a seismologist had data on one earthquake from several instruments at different points of the globe, they could evaluate how waves traveled through the earth. They also hoped it would help them understand the cause(s) of earthquakes, such as whether they were tectonic in origin or caused by a subterranean explosion. By tracking the movements of the earth, seismologists hoped that they would be able to establish a sequence of events that led up to an earthquake, potentially allowing seismologists to predict earthquakes.[139] As scientists acknowledged the necessity of earthquake data from all over the earth, the colonies were their main points of contact to gather this information. The data from colonies was an indispensable part of making seismology a truly global science. Although the necessity of observations in colonies was obvious, the methods to collect information were less so. Seismologists were trying to decide what seismology would need to look like to best accommodate all locations and goals for the discipline.

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[138] Coen, *Earthquake Observers*, 184.
[139] Harry Fielding Reid, “The Problems of Seismology,” *Geophysics* 6 (1920): 559-60.

Seismology circa 1900: The Debate

During the very beginning of the twentieth century, scientists decided to form the International Association of Seismology (ISA) in an "example of building an international organization and running collaborative projects."[140] By 1904 the ISA was up and running. Seismologists realized that to understand the inner workings and composition of the earth by using earthquake data, they would need information about earthquakes from around the world. Indeed, the ISA stated that one of its most important functions was to publish thorough up-to-date catalogues of worldwide earthquakes.[141] The main question, then, was how to best go about collecting information. Coen identifies the basic debate in seismology as whether the science needed to continue with its fieldwork focus or shift the bulk of the work to observatories. Fieldwork was the main data gathering activity of macro-seismologists, who believed that examining the surface of the earth and secondary effects yielded useful results to seismology and society. Observatory work, which used primarily instruments, was the main activity of micro-seismologists (or, as Oldham wanted to call them, crypto-seismologists) as they believed that instrumental inscriptions yielded the best information about earthquakes from around the world. The underlying question was whether seismology fit more appropriately as a subdiscipline of geology or as a subdiscipline of geophysics. If a type of geology, then it was more important to

[140] Elisabeth Crawford, *Nationalism and Internationalism in Science, 1880-1939: Four Studies of the Nobel Population* (Cambridge: Cambridge University Press, 1992), 42; Coen, *Earthquake Observers*, 163.
[141] "The International Association of Seismology," *Nature* 77, no. 1986 (1907): 61. https://rdcu.be/LQb0.

spend the most effort engaged in fieldwork, and if a geophysics discipline, then it was more appropriate to stay in an observatory and monitor instruments.

As Helen Tilley warns, it would be inappropriate to draw "too sharp a dichotomy between laboratory and field methods, since many disciplines relied on both techniques…[t]he 'field' was essential to everyone."[142] However, Coen points out that seismology was an especially contentious field when it came to deciding whether laboratory work or fieldwork was more important.[143] She argues that fieldwork showed seismologists the importance of "vernacular science and the complexity and specificity of human-environmental interactions" and that when it was reduced to observatories with instruments, "seismology became all too easy to assimilate to the simplifications of an imperialist worldview."[144] George Gerland (1833-1919), the director of the Imperial Seismological Station in Strasbourg and president of the ISA, fell firmly in the camp of the seismology as an observatory science, while other famous geologists, such as Eduard Suess (1831-1914) and Fernand Montessus de Ballore (1851-1923), were more skeptical of Gerland's agenda.[145] Seismologists that leaned towards a fieldwork approach did not discount the role of instruments — they used them themselves and solicited instrument inscriptions from fellow seismologists — but they believed

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142 Helen Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950* (Chicago: University of Chicago Press, 2011), 318.
143 Coen, *Earthquake Observers*, 186.
144 Ibid.
145 Ibid., 163-186.

that the peculiarities of each location made it necessary to get out of the observatory to survey each location individually.

Fieldwork

Macro-seismologists argued that understanding and documenting an earthquake as a disaster was an essential part of being a seismologist. Scientists had an obligation to use their science to help the regional populations, so, they argued, seismological fieldwork surveys needed to be conducted at the regional, rather than global, level.[146] They hoped that by identifying places and structures of heightened risk, they would be able suggest real solutions to the problems.[147] This type of work was intensely collaborative, requiring seismologists from around the world to survey and report on earthquakes from several different regions around the world. It required a more or less permanent network of observers constantly keeping tabs on the earthquakes happening around them. Instead of being a network of trained instrument observers, it would need to be a network of geologists trained to observe earthquakes, possessing a certain amount of tacit knowledge that only fieldwork could hone. These types of surveys resulted in the isoseismic maps. As Clancey said, "The isoseismal map was the geographic expression of an earthquake as the seismograph was its geophysical one."[148] Unlike in micro-seismology, local knowledge was valuable data, and seismologists, especially in Switzerland, collected it along with their more

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[146] Ibid., 163-64.
[147] Ibid., 163-64, 171.
[148] Gregory Clancey, *Earthquake Nation: The Cultural Politics of Japanese Seismicity, 1868-1930* (Berkeley: University of California Press, 2013), 154.

'scientific' observations.[149] One reason particular to this time for choosing fieldwork over observatory work was to corroborate Suess' theory of mountain formation.[150] Fieldwork helped connect seismically active zones with mountainous regions, an important part of Suess' claims.

Even though seismologists such as Suess and Montessus sustained macro-seismology's fieldwork as a necessary part of seismology and a socially responsible practice as well, the methods carried a lot of problems too. Conducting work in the field was time consuming, and seismologists had to deal with variations in weather and landscape. In Oldham's case, he had to conduct the survey during a cold and rainy season and elected to not climb the Himalayas in search of evidence. He was also constrained by political boundaries. Fieldworkers were limited in their reach by geopolitical borders as much as physical boundaries. Each earthquake region presented a different set of difficulties to be solved by the seismologist, and each required unique adjustments to the methods, tools, and responses of the seismologist. They needed to not only be skilled in the general profession, but flexible enough to tinker with observational seismology to make it an appropriate fit for their region. Scales had to be adjusted according to the peculiarities of the location and population. As already shown, this was often because of social reasons as well as physical ones. Although scientists often gave

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[149] Coen, *Earthquake Observers*, 171; Clancey, *Earthquake Nation*, 159. Even though local knowledge was *generally* more valued in macroseismology, it was not a given, as Oldham's report demonstrates. In Switzerland, seismologists were able to work out a system of educating the public and also helping them structure their responses so that the public became a type of expert.
[150] Coen, *Earthquake Observers*, 163-4.

rough approximations between their scale and the Rossi-Forel, the result was not a more descriptive and thorough scale but a less informative one. The isoseismal maps they could draw were also less defined, and there were usually fewer levels of intensity. For example, Oldham's scale only had six levels, while the Rossi-Forel had ten.[151] Seismologists struggled with trying to make a universal scale, with some seismologists giving up on the task, instead suggesting that each seismologist should come up with his own according to the situation.[152] It also meant that the seismologist had to rely heavily on local populations and knowledge and trust the locals about the effects of earthquakes, their frequency, etc. Unless the seismologist was native to the area himself, the most efficient way of understanding an area was to establish communication and trust with the people who had lived there. This was problematic in making a global seismology, as data from colonial outposts began appearing in Europe but it was not as specific as they hoped it would be. It started tearing apart their previously accepted scales, but did not provide alternatives, leaving the comparative scales less useful and the data less specific.

Instruments and Observatories

Instruments, supporters reminded the public and their opponents, made seismology a truly international science. Seismologists hoped that by using instruments they would no longer have to worry about being in the right place at the right time to experience an earthquake and conduct a survey. With sufficiently

[151] Davison, *Great Earthquakes*, 140-41.
[152] Coen, *Earthquake Observers*, 176-80.

sensitive seismographs, seismologists from around the world, even those living in non-seismic countries, could participate in collecting and verifying information, and be able to engage in active debate with other seismologists in more earthquake-prone areas.[153] Not only would this bring the science to a broader range of scientists, Milne argued, but it would help the discipline overall to accomplish its goals:

> The records of these ubiquitous breathings of the earth's surface, the observation of which is at present confined to one or two observers, constitute a new departure in an old study, and promise to throw new light upon the physics of our earth's crust and the nature of its interior.[154]

With instruments, seismology would be able to detect and record the primary effects of earthquakes, or, in other words, they would be able to measure the magnitude of an earthquake. As shown in the previous chapter, observational methods depended on secondary effects, such as building damage, to measure earthquakes. Proponents of this 'new' seismology wanted to remove the uncertainty and margin of error that came with observational seismology, which Oldham emphasized in his report. Theoretically, the instruments and the scales could be standardized to eliminate the need for reconciling all varieties of data. Because it was based in an observatory and did not require hefty amounts of fieldwork, the observatory seismologists could produce information about earthquakes much more quickly than field seismologists. In addition to these practical benefits, seismologists believed that instrumentally and observatory-

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[153] Milne, *Seismology*, v.
[154] Ibid., v-vi.

based scholarship made the entire discipline more scientific.[155] By more scientific, they meant that seismology would be based more on the methods of physics rather than on geology. According to Gerland, by transitioning to the observatory, seismology would become a purely intellectual science.[156] This made seismology a more foundational science according to Auguste Comte's (1798-1857) influential hierarchy of the sciences, as it supposedly relied on more physical and general laws than observational seismology.[157]

But observatory seismologists faced several challenges as well. Despite their supposed benefits, the several types of seismographs were finicky. Because there were multiple types of earth movements, multiple types of seismographs existed to measure each. To use Wiebe E. Bijker's term, the field had not achieved closure on what constituted a working seismograph and an accurate seismogram.[158] Seismologists had not standardized these instruments, so seismographic data came in all varieties. As Andrea Westermann explains, the Seismological Association responsible for collecting information from seismographs across the world failed, for many years, to address the issue of standardizing the information flooding in. In 1909, the director explained that,

> The situation is such...that many important circles, especially in England and Russia, have lost confidence in the central bureau. An immense and

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[155] Coen, *Earthquake Observers*, 163, 166-7.
[156] Ibid., 166-67.
[157] George Henry Lewes, *Comte's philosophy of the sciences,* (London: Bell & Daldy, 1871), 98-100.
[158] Wiebe E. Bijker, *On Bicycles, Bakelites, and Bulbs*, (Cambridge: The MIT Press, 1997), 270.

> growing mass of observational data is sent to Strasbourg, but nobody is able to process it for further scientific interpretation.[159]

Most of the instruments were still being tested in Japan, as seismologists were continually tweaking them to see if they could measure different types of movements.[160] Complicating this was the relative discontent with the current theories of earth processes, the causes of earthquakes, and the material structure of the earth's interior. It is difficult to find a seismologist who spoke about the most commonly accepted theory of the causes of earthquakes using absolutist terms. Oldham did not use definite language when referring to these theories.[161] He was not alone in his tentative acceptance of the theory. Milne was also cautious in his discussion of the underlying geophysical causes of earthquakes, saying that the current theories were "not unlikely" and "not impossible."[162]

According to the predominant theory that seismologists used, the earth was a cooling mass composed of three portions. A completely cooled outer skin of rock kept a constant temperature, while the second shell of rock, sitting underneath the shallow skin, was gradually cooling and contracting. A third "central mass" had not yet lost its heat, so it was still in a more viscous state.[163] As the second shell of rock gradually cooled, it contracted around the central mass. Somewhere between the superheated center and the cooling shell, there was

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[159] Andrea Westermann, "Disciplining the Earth: Earthquake Observation in Switzerland and Germany at the Turn of the Nineteenth Century," *Environment and History* 17, no. 1 (Feb 2011): 75.
[160] Milne, *Seismology*, 39.
[161] Memoir, 176.
[162] Milne, *Seismology*, 86-87.
[163] Memoir, 176.

a level of no strain, where the tension of the central mass canceled out the tension of the shell.[164] The two central portions of the earth, then, were cooling and contracting at a slow and gradual rate. The unyielding outermost skin, however, did not have its compression counteracted by tension, and it could not support its own weight. This meant that when the shell contracted, the space left between the shell and the skin would generate strain in the skin. Eventually, this strain would accumulate until it finally fractured under its own weight, causing a tectonic earthquake.[165] Oldham also listed two other possible causes (although there were more than three accepted causes at the time, he only listed those which he thought were the most likely causes). Earthquakes could also be the result of rockfall in subterranean caves and volcanic activity that released the earth's pent-up steam.[166] Each supposed type of earthquake needed several types of seismographs to track it.

But there was not much consensus on what a correct seismogram should look like, or even what type of data was best to collect. For several rockfall earthquakes, the only data that could be used was the sound it caused rather than the vibrations it produced. Volcanic earthquakes did not produce waves deep enough for the earthquake to register outside of the immediate vicinity, and seismographs were incapable of reading earthquakes that they sat directly on top of. Oldham acknowledged that this was the problem with the few seismographs set up in India.

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164 Ibid., 177.
165 Ibid., xxiv-xxv, 176-77.
166 Ibid., xxiv.

> The record vary much in value according to the nature of the instruments employed. In many cases these were in reality too delicate, and, under the influence of so exceptionally great a disturbance as was set up by this earthquake, the record of all but the beginning and end was lost.[167]

Although seismologists thought that different wave types produced by tectonic earthquakes existed, they did not have (instrumental) proof, but still tried to measure them nonetheless by setting up multiple types of instruments to capture as much variation in movement as they could.

Another problem was that the earth refused to be still. In 1920, seismologists still complained about near constant and unexplained microseisms that shook their seismographs, even in the absence of earthquakes.[168] Ironically, even though seismographs were designed to register earth movement, instruments that registered too much earth movement interfered with tracking the ‘important’ terrestrial activity. Consequently, seismologists had to use seismographs that were *less* sensitive alongside their highly sensitive machines so that they could limit the number of tremors recorded.[169] Isolating the waves that seismologists deemed relevant to seismology continued to be problematic. Often, these signals of an active earth made seismologists rely on each other to verify whether the tremors their instruments registered were worldwide events. They had to determine what earth movement to ignore, what warranted verification, and what counted as seismologically relevant.

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[167] Ibid., 228.
[168] Reid, “The Problems of Seismology,” 559-60.
[169] Ibid., 558.

As the instrument observers discovered, the sensitive instruments could not be set up just anywhere. Making a seismograph inscribe exclusively the earth's own movement turned out to be remarkably difficult. Everything from a nearby factory to the moon affected the delicate instruments.[170] In a beautifully ironic twist, the technologies that Oldham had used to observe the earthquake became problematic for seismographs. Trains, traffic, steamboats, buildings, and bridges all caused minute vibrations on the surface of the earth (but not the microseisms discussed previously), causing a seismograph to falsely register earth tremors.[171] Scientists developed a few ways to solve these problems, but they usually involved altering the landscape. Some seismologists dug trenches around their instruments, sometimes 40-60 feet deep, to insulate them from the effects of human activities and inventions.[172]

Setting up a seismograph network was also expensive, which made it especially difficult for colonial seismologists. In 1883, Oldham said about building several seismographs, that "the expenditure is not one that could be recommended to Government."[173] The cost of seismographs was a problem that the ISA recognized, and they even sponsored a prize for the best cheap

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[170] Milne, *Seismology*, 299, 263.
[171] Ibid., 297-99.
[172] The evidence that seismographs could be insulated in this manner came from fieldwork, which showed that structures far enough away from the angle of emergence were unaffected by surface waves if surrounded by an adequately deep trench. Mines, if they were deep enough, also escaped damage from earthquakes. Memoir, xv.
[173] Memoir, 1883, 98.

seismograph.[174] Instead of asking the government for the funds, Oldham encouraged people to construct their own and instructed them in how to observe these makeshift seismographs.[175] The nature of conducting seismological work, and especially work in colonies, necessitated a special variety of instruments as well. Oldham said that instruments used in colonies needed to be easy to transport, must not occupy a large amount of space, must not require special foundations, be inexpensive, run without much attention, be consistent and sensitive (but not too sensitive), and the "records should be capable of easy and rapid reproduction."[176] As Oldham said, European seismologists working in observatories might not see the value of such instruments, as they were not facing the same set of circumstances. Running an observatory with the most current, accurate, and expensive instruments was time consuming and cost intensive. Colonial seismologists did not have these luxuries, so their instruments should be made to fit their particular needs rather than the needs of, for example, 'Strassburg,' one of the most important earthquake observatories.[177]

Montessus de Ballore criticized using seismographs exclusively, since he believed that they missed important effects of earthquakes. According to him, "[s]eismology could not be confined to the observatory, for its evidence was

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[174] Harry Fielding Reid, "The Meeting of the International Seismological Association." *Science* 27, no. 680 (1908): 74-76. http://www.jstor.org/stable/1632168.
[175] Memoir, 1883, 89-98.
[176] Oldham, "Seismographs and Seismograms," *Nature* 77, no. 1994 (January 2018): 246-47.
[177] Ibid., 246.

written in part on the face of the earth."[178] A later problem with observatories and seismographs that was not obvious at the turn of the century was the issue of national security. The ISA fell apart at the beginning of the first World War, and with World War II, "plans for a dense and truly global network of seismometers ha[d] failed in the face of objections that such surveillance would compromise national security."[179] Despite the idealistic portrayal of observatories and seismographs, the realities left the ideal mostly that - an ideal. As an observatory science, seismology started taking apart an earthquake as a disaster.

Oldham's Arguments

Oldham refuted the arguments of macro-seismologists using examples from his own colonial work in India in an effort to push the field in a geophysical direction. His 1899 report argued that observational methods were unsuitable for colonies. He believed that this was unacceptable because of the necessary data that could only be obtained from countries outside of Europe. In his later work, he sought to prove that instruments were not simply a better alternative; they were an excellent option for seismology in Europe and colonies alike. Instruments, he believed, addressed the problems he encountered in conducting his colonial seismology.

One of the most critical problems he identified in his work was the problem of working in India with the Indian people. India and its population were not conducive to conducting surveys, he asserted. However, the earthquake data

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[178] Coen, *Earthquake Observers*, 169.
[179] Ibid., 184.

gathered from India was essential, as it was one of the key seismic zones, being near a mountain range, and any earthquake data from outside of Europe was critical to making seismology a universal science. Throughout his report, Oldham downplayed Indian contributions, disguised indigenous knowledge, and emphasized the lack of data. Through Oldham’s writing and remarks, readers of his report are given the impression that valuable data about the earthquake is inaccessible thanks to a lack of civilization and the harsh landscape of India. This colonial point of view provided micro-seismologists with better evidence for pushing for a network of instruments. As Clancey says, the seismologist Davison came away from Oldham's report feeling that the report was a "triumph of European science amid difficult local conditions."[180] Oldham does not suggest measures that integrated indigenous knowledge, such as changing building style, replanting some of the forest in the lowlands, or creating a network of communications with the Garo and Khasi people. The only suggestions he offered, both in his earthquake report and the report that he compiled for his father, was to install seismographs across the subcontinent.[181]

Cooperation from the local population was not a given in India. Local groups could be hostile to colonial efforts, or there could be a language barrier. Indians may have had different reactions than Europeans, so their reactions to earthquakes could not be trusted as seismological evidence. In addition to the population, the landscape and political situations posed problems. Observing

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[180] Clancey, *Earthquake Nation*, 159.
[181] Memoir, 1883.

instruments in the safety of an observatory seemed like an easier and more efficient option. Human error plagued his report, and he blamed most of this on the lack of large settlements across Assam. The natural consequence of these realities, Oldham implied, was that observational seismology needed to be stripped down to a simplified version that did not yield data as rich as seismologists in Europe could produce. Observational seismology would always be less complete and thus less helpful due to the unique problems facing colonial seismologists. Colonial seismology was too critical to seismology as a field overall to be left to Mallet's methods or indigenous observations. Interestingly, he never suggested ways to overcome these individual challenges. Rather, the only good solution, Oldham argued, was the instrument network. Using instruments, he believed that he would be able to transcend the complications of places like India. Although he acknowledged the problems with the seismographs currently in India, and noted that human error could still enter in, he still placed his faith in instruments and seismology’s geophysical shift.

Inadequate instruments would not be problematic enough to keep them from being the primary method of data gathering according to Oldham. In his later work, he continued to rely on instrumental data gathered during his earthquake survey to show the value of seismology as a geophysical science. In histories of seismology, Oldham is remembered as the geologist who discovered that there were three distinct types of seismic waves and provided the first evidence for the earth's core, which he calculated to be about 0.4 the radius of the earth.[182] Oldham's faith in instruments did not lay solely with seismographs. He used a wide variety of instruments, of which only some were considered strictly earthquake-recording instruments, to track waves across the surface of and through the earth. Simultaneously, John Milne (1850-1913) was involved in setting up a sparse network of seismographs. Unfortunately, very few of the seismographs were sensitive enough to record anything but large quakes. It was not until later that Emil Wiechert (1861-1928) figured out how to dampen seismographs, which lessened the amount of excessive movement of the seismograph, decreasing the amount of seismograms recording movement that was non-tectonic in origin, that the instruments rendered more accurate results.[183] Despite the instrumental flaws, Oldham was confident enough in his measurements to challenge Rayleigh's theory of surface waves. Subsequently, Oldham got the credit as being the first discoverer, as he had provided instrumental data.

Similarly, geologists and geophysicists for long had hypothesized about a liquid center of the earth. It was his measurements of earthquake waves, using instruments from around the globe, that earned him the recognition as the 'discoverer' of the core of the earth. Echoing his opinions formed during his time in colonial India, he credited instruments in Europe, and a little bit of luck, in his discovery.

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[182] William Bragg, "Tribute to Deceased Fellows of the Royal Society," *Science* 84, no. 2190 (1936): 544. http://www.jstor.org/stable/1663153.
[183] Duncan Carr Agnew, "History of Seismology," in *International Handbook of Earthquake & Engineering Seismology, Part A* (London: Academic Press, 2002), 6-7. https://igppweb.ucsd.edu/~agnew/Pubs/agnew.a66.pdf.

> [They were] practically made possible by the fact that in 1906 there were two great earthquakes, both of which were large enough to give very complete records at distant stations; both of which originated at about the same distance from the group of seismological stations in Western Europe, but in such positions that the wave-paths differed radically in type.[184]

The network of instruments, placed at strategic points in Europe, Asia, and the Americas, was what allowed Oldham to generate his measurements and conclusions. To Oldham, this was proof that showed how seismographs, placed across the earth, could give seismologists the material they needed to answer geophysical questions. Until instruments were invented, he said that seismologists did not have the tools to measure the interior of the earth. Instrumental seismology opened up the earth for exploration. 'Confining' exploration and theorization to the earth's crust, Oldham suggested, was a fault in the discipline of geology, which instruments could finally remedy.

> Many theories of the earth have been propounded at different times: the central substance of the earth has been supposed to be fiery, fluid, solid, and gaseous in turn, till geologists have turned in despair from the subject, and become inclined to confine their attention to the outermost crust of the earth, leaving its centre as a playground for mathematicians. The object of this paper is not to introduce another speculation, but to point out that the subject is, at least partly, removed from the realm of speculation into that of knowledge by the instrument of research which the modern seismograph has placed in our hands. Just as the spectroscope opened up a new astronomy by enabling the astronomer to determine some of the constituents of which distant stars are composed, so the seismograph, recording the unfelt motion of distant earthquakes, enables us to see into the earth and determine its nature with as great a certainty, up to a certain point, as if we could drive a tunnel through it and take samples of the matter passed through.[185]

[184] R. D. Oldham, "The Constitution of the Interior of the Earth," *Quarterly Journal for the Geological Society* 63 (1907): 344. https://hdl.handle.net/2027/njp.32101083531630.
[185] R. D. Oldham, "The Constitution of the Interior of the Earth, as Revealed by Earthquakes," *Quarterly Journal of the Geological Society* 62 (1906): 456. https://hdl.handle.net/2027/njp.32101083531671.

No matter how thorough his observational report, he was arguing, that only instruments could provide answers to geophysical questions. The course of Oldham's career demonstrated, as he hoped it would, why instrumental seismology was so valuable, and how it could be used to answer some of the fundamental questions of geophysics, such as what the interior of the earth looked like. All of this he attributed to instruments. These conclusions rebutted the macro-seismologists' argument that inadequate instruments should not be used as the primary form of data. The seismograms were too variable and were affected by too many outside influences to be as dependable as a seismologist's observational data. However, Oldham showed (although his proofs were not uncontested)[186] that imperfect instruments, some not even intended for seismology, could provide answers to the questions that were now the most important for geophysicists.

Oldham's insistence on using instruments as the primary source of data in seismology was a defining characteristic of his seismology. His opinions about the methods of seismology and the benefits of instrumentalizing seismology were formed in response to his work as a colonial seismologist. Although he never condemned observational seismologists and their methods outright, his arguments placed him squarely on the side of the geophysicists. If seismologists wanted a universal science, especially including the colonies, the best course of action that mitigated the problems of conducting seismological surveys in a colony was to

[186] Agnew, "History of Seismology," 7.

turn to instruments, regardless of their flaws, and invest time and effort into making them more accessible.

Oldham ended up with the reputation he had hoped for. His work was quickly influential in seismology and geology. His report, along with his work on the center of the earth, was what he was best known for.[187] In retrospect, seismologists labeled it "quite the most valuable work prepared up to that time"[188] and some gave the overly generous evaluation that his report "laid the foundation of modern seismological studies [and] will remain forever a classic contribution."[189] Suess used his work in theorizing about the composition of the earth and the origins of mountains.[190] Due to his status as an important geophysicist, Oldham later weighed in on the debate about Wegener's plate tectonic theory.[191] In obituaries, Oldham was contrasted with Mallet, showing his report as an example of the next step in seismology between Mallet and the 'new' seismology.[192] He also trained other seismologist-geologists working in India. Charles Stewart Middlemiss (1859-1945), who compiled the report on the 1905 Kangra Earthquake, attributed his methodology to Oldham's training.[193] Along

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[187] Davison, "Richard Dixon Oldham," 111.
[188] Ibid., 112.
[189] V. S. Krishnaswamy, "Foreward," in *Memoirs of the Geological Survey of India* vol. 29. 1981 Reprint (Calcutta: Office of the Geological Survey, 1899.)
[190] Mott T. Greene, *Geology in the Nineteenth Century: Changing Views of a Changing World* (Ithaca: Cornell University Press, 1982), 269.
[191] Mott T. Greene, *Alfred Wegener: Science, Exploration, and the Theory of Continental Drift* (Baltimore: Johns Hopkins University Press, 2015), 480-82.
[192] Charles Stewart Middlemiss, "Obituary Notice of Richard Dixon Oldham," *The Quarterly Journal of the Geological Society of London* 93 (1937): lxxvii. http://jgs.lyellcollection.org/content/jgsleg/93/1-4/i.full.pdf.
[193] Ibid., ciii-civ; *Memoirs* vol. 38, (1910).

with being remembered as an important seismologist, he is also celebrated as a scientist who overcame problematic circumstances in colonies, and used instruments to prove important geophysical theories. He was the seismologist who pressed on 'despite' the difficulties of colonial seismology. As he wanted to do, he demonstrated the necessity of colonial data being gathered by instrument through his work. The primary questions he hoped to answer, the geophysical, were the ones he was remembered for.

Japan, the Successful Alternative

Seismologists working in Japan faced very similar situations as Oldham did in India. Their choices, however, reveal a very different direction Oldham could have taken. Although I provide it as an alternative model, it is important to keep in mind other differences that influenced their decisions. First of all, Japan was not Britain's colony, so the Japanese government could decide on the measures that would best suit Japan, rather than considering whether their work would primarily benefit Great Britain. Japanese seismologists had as much agency in constructing Japanese seismology as Milne did. Despite the heavy influence from Britain through Milne and other seismologists, Japanese seismologists determined that the most pressing issues were learning how to predict earthquakes and learning how to build structures that resisted seismic shocks.[194] Although Japan was not a colonial outpost, seismologists valued the data from Japan because it fell outside of Europe's geography. The Japanese

[194] Kikuchi, "An Earthquake Investigation Committee," Nature, 418. https://www.nature.com/articles/046418a0

government decided to form the Imperial Earthquake Investigation Committee in 1892, hiring an initial thirteen seismologists, engineers, and scientists from other disciplines.[195] The government provided yearly funding for the committee. Oldham, on the other hand, was the only seismologist working in India, and only initially had the help of a few other geologists for the survey. They also had poor funding. The purposes of the committees were different. Oldham was instructed to write a report from a 'scientific' point of view, which meant that he was not supposed to record deaths or near-deaths and was not instructed to predict earthquakes.[196] In addition to the special committee, the Japanese also included seismology in their education programs. This was absent in India, as the teaching of geology in universities was already a controversial practice.[197] Seismologists and engineers in Japan built and tested several seismographs, something that was not done in India. Although Oldham had explained how to construct some simple seismographs in India, the government overall did not take an interest in funding seismograph development.

Seismologists in both locations had difficulty in collecting data from the public. In India, Oldham required an interpreter and many of the people he conversed with would have been hostile to the colonial government. In Japan, collecting reports from the public was difficult because Japan experienced so many earthquakes, and Milne seems to have given up on collecting after the 1880

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[195] Ibid.
[196] Memoir, 2-3.
[197] See Kumar, "Economic Compulsions," and Kumar "Science and the Raj."

earthquake.[198] Overall, Japanese seismologists had the independent government, funding, organization, and directives to do seismological research that was absent in colonial India. But two particularly revealing differences cannot be explained away by systemic differences. Japanese seismologists believed in the social obligations of seismology and valued public contributions, at least initially.

Milne and Fusakichi Ōmori (1868-1923), two of the most important seismologists working in Japan, handled the question of public responsibility and public engagement differently. They did not align themselves with either the macro or micro-seismologists. Even though there were seismologists that fit squarely in one camp or the other (Gerland is an example of this, as he "dismissed outright all the work his colleagues were doing to avert future disasters - the mapping of seismic intensity, the location of fault lines, the study of architectural damage."[199]), several of the seismologists fell somewhere in a middle ground. Coen's dichotomy is misleadingly simple; most seismologists believed that both fieldwork and observatory work were necessary, that instrument readings filled in the gaping holes in observational seismology's methodology, and that seismologists had an obligation to identify areas of increased vulnerability and suggest measures to mitigate the disastrous effects of earthquakes on humans. Milne and Ōmori are perhaps the most famous example of this. They advocated for the use of instruments primarily, and, when faced with the problems of conducting observational seismology in Japan, mostly abandoned the

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198 Coen, *Earthquake Observers*, 17.
199 Ibid., 167.

observational technique. But their seismology was anything but 'purely intellectual.' Every bit of their research had practical applications, from building more efficient structures (which they tested on machines) to laying undersea telegraph cables. Both actively favored a collaborative approach, working with and training Japanese students and seismologists to come up with methods, instruments, and an architectural style most suitable for Japan. When comparing Japan's seismology with India's, Clancey says that,

> To Davison, areas where no observations could be obtained map land inhabited by ignorant or illiterate tribes. Ōmori maps them, in the Japanese context, as areas of indigenous skill and stability. To Davison, the work of the Indian Geological Survey is a triumph or European science amid difficult local conditions. To Ōmori, isoseismal lines trace out the failure of European science to come to terms with unexpected local difficulties.[200]

Although this misrepresents Oldham's work, it captures the differences between their two methods. Oldham, Ōmori, and Milne all addressed the problem of making seismology across the globe comparable the same way. Each believed that seismographs would allow scientists from all over the world to assess the earthquakes by the same standards. Clancey recognized, however, that valuing seismographs above communication with the local population was a colonial practice. "Object-based or instrumental seismology was...simultaneously a set of colonizing practices and a potentially powerful commentary on the colonial project itself. As long as Ōmori relied solely on physical markers, questions about the reliability of Japanese witnessing would never be raised."[201]

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[200] Clancey, *Earthquake Nation*, 159.
[201] Ibid., 158.

The primary difference lay in the function they imagined these seismographs served. Oldham wanted the entire discipline to be geophysical in nature and used colonial impediments to prove the necessity of instruments. Milne and Ōmori used seismographs as a way to overcome some of the regional variations between Japan and the West, but also used them to show that they could be beneficial to engineering, architecture, and prediction. In addition, Ōmori and Milne learned to read the Japanese landscape and architecture for earthquake data, even going so far as to compare Japanese architecture with seismological instruments, while Oldham labeled the Indian architecture and society problematic for earthquake observations.[202]

Conclusion

To both micro and macro-seismologists, the necessity of data from numerous points around the world was indisputable. But colonies and their earthquakes were hotly contested spaces in the seismological debates at the end of the nineteenth century. Which types of information from these places were valuable to the seismological debates held in Europe? What were the social obligations to those who lived in these areas? What, if anything, should scientists learn from local people? What were the best ways to address the discrepancies between different points on the globe? And how was relevant evidence best collected from these sites? Seismologists working in colonies were in a uniquely powerful position to answer these questions. Their decisions and recommendations, as exhibited in their reports, were far from an unbiased reading

[202] Ibid., 66-71.

of the facts. Each report was an argument for how to answer these questions, and the conclusions suggested by the authors were informed by both social and physical considerations. In India's case, Oldham presented an argument that pointed to the inadequacy of observational seismology in the colonies. The barriers to conducting adequate and informative surveys, his report suggested, were too problematic to overcome with simple adjustments to the methodology. In areas of the world that had even less European structures and infrastructures, seismology would be impossible, and the potential seismic data would be lost. Instruments were the best solution. Not only could they transcend the problems of colonial seismology, they could also give scientists evidence for unsolved mysteries of the earth's center.

Despite trying to eliminate the 'colonial' from colonial seismology, Oldham's suggested solutions replicated many of the colonial hierarchies of power. It further insulated Europeans from the various peoples they worked among. In instrumental seismology, Indian voices were again silenced, their aseismic architecture overlooked, and their knowledge and methods of observation rendered frivolous while instruments' contested inscriptions were elevated. As Oldham was trying to look deeper into the earth, the Indians, who only occasionally showed up in his report, began to fade completely from view. Seismographs could track and measure the earth's waves, but the disastrous nature of an earthquake was reduced to a simple natural process that exposed the unseeable and hid the obvious.

It is unclear how these arguments would have played out without the World Wars. While seismologists were still making sense of these questions, the data, and the instruments, World War I interrupted. Seismology and its global networks were pushed down the list of priorities, and instrumental seismology lost its "purely intellectual" persona in favor of a science that could serve the nation. When seismologists revisited these questions, they were also dealing with new seismic readings, a new theory of how the earth worked, and new war technologies that they could use. Still, seismologists look back on this moment, the rocky transition from observational to instrumental, as the foundation of a truly modern seismology. Missing in this foundation myth are the questions of responsibility, the question of the purpose of seismology, and the continuing influence of colonialism.

Chapter 4: Conclusion

Oldham did not stay long in India after he published his report, returning to Great Britain in 1904. He had recently been passed over for promotion but had also contracted sprue, which he died from in 1936. After he returned to Europe, Oldham continued to write and publish papers on earthquakes, during which time he compiled his seismograph inscriptions to show that the earth had a viscous core and that there were three distinct types of earthquake waves. [203] These two discoveries earned him a Lyell Medal (1908) and the presidency of the Geological Society (1920-22), as well as a place on history of seismology timelines. As one such entry describes him, “He was a geologist with little passion yet was the first to discover p-waves and s-waves in seismograms. He also discovered the Earth’s core using seismic waves.”[204] Undoubtedly, his experience in India shaped the way he thought of and wrote about seismology. He decided that a universal seismology would need to be an instrumental seismology, and the discipline would need to focus its attention on the interior of the earth rather than the effects on the surface. As he said, his seismology “must savour of cold-bloodedness; yet the human suffering will pass [and] the ruined cities will be rebuilt.”[205]

Globalization, and especially colonialism, had shaken the tenets of seismology. Geophysicists’ solutions, and the resulting ‘new’ seismology, was a reaction to the application of seismology to locations across the world, rather than

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[203] Middlemiss, “Richard Dixon Oldham,” ciii-cvi.
[204] "The History of Seismology," Preceden. https://www.preceden.com/timelines/40019-the-history-of-seismology.
[205] R. D. Oldham, “The Italian Earthquake of December 28, 1908,” *The Geographical Journal* 33, no. 2 (February 1909): 185.

just in European cities. Encountering new problems and types of evidence, seismologists had to make a decision about how seismology needed to change to be a universal science. The result was an instrumentalist shift in the discipline. This shift was not simply adding instruments to the already existing framework; seismologists had to restructure what seismology was a science of, what counted as credible evidence, and who could do the observing. It privileged one form of knowing, instrument inscriptions, over the human experience and secondary effects.

Oldham, in his report, selected what counted as usable evidence, and usually this meant ignoring the Indian evidence of testimonies, architecture, and observation techniques. In the Assam example, Indians were not agents in constructing a universal seismology; when included, they serve merely as informants rather than as active and educated partners in knowledge-making. By examining the Japanese case, where Japanese and British seismologists worked together to create a hybrid seismology, we can see that suppressing indigenous knowledge is not inherent in instrumental seismology. However, Oldham framed the geophysical turn as incompatible with non-European knowledge. Being one of the few sources from a colonial 'outpost,' Oldham's arguments were influential in creating a universal science. This universal science had to be able to transcend place and be applicable anywhere. Embedded in these assumptions, however, are the assumptions of the uselessness of Indian (and other non-European) knowledge and the invisibility of the experiencers. The distrust of indigenous people was an issue that did not have to be resolved in the new seismology. The 'modern' seismology that emerged from this crucible reproduced the invisibility of the colonized and of their knowledge.

Although instruments helped seismologists gather data quickly, made their data comparable to other seismologists', and simultaneously observe seismic events from around the world, transitioning to an instrumental seismology was problematic. The most important problem was that, despite seismologists' ample praise of instruments, there was no settled epistemology to transition to. There was not much consensus about what seismographs measured, what they were supposed to measure, how much of it to measure, and whether seismograms accurately inscribed what they were supposed to record. Colonial seismology also made demands on the construction of the instruments, including requiring inexpensive, portable designs. Consequently, hundreds of types of seismographs existed, matched by hundreds of types of data that they recorded. The debate was not between two established types of seismology. It was between an established, but inadequate, method and a method currently in production. As seismologists converted to instrumental seismology, they contributed to shaping the amorphous epistemology. Questionable as this new seismology was, Oldham argued that unreliable instruments were less problematic than unreliable people, proving it through his later publications. He put his faith in the improvement of instruments rather than the education of the public.

The instrumental turn in seismology was a very deliberate, contested change, a story antithetical to the traditional narrative of the development of modern seismology. Colonial seismologists directly affected this change, providing evidence and arguing for the necessity of instruments. Seismological theories of the earth shifted during the first world war, but Oldham's argument captures the thoughts and attitudes of many seismologists that brought 'new' geophysical seismology to the forefront of the discipline. It relied on instruments and data, using technology and methods that were nowhere near closure. Like Mallet's Europe-bound methodology, Oldham's version of a 'new' seismology was bound to its origins in globalization and colonialism.

References

Primary

A Handbook for Travellers in India Burma and Ceylon, including the Provinces of Bengal, Bombay, Madras, the United Provinces of Agra and Lucknow, the Panjab, the North-west Frontier Province, Beluchistan, Assam, and the Central Provinces, and the Native States of Rajputana, Central India, Kashmir, Hyderabad, Mysore, etc. 6th ed. London: John Murray, 1908. https://hdl.handle.net/2027/hvd.hnbp7w.

Assam: Sketch of its History, Soil, and Productions; with the Discovery of The Tea-Plant and of the Countries Adjoining Assam. With Maps. London: Smith, Elder, and Co., 1839. https://hdl.handle.net/2027/umn.31951002324130v.

Ball, Valentine. *A Manual of the Geology of India, Part III: Economic Geology*. London: Trübner and Co., 1880.

Bragg, William. "Tribute to Deceased Fellows of the Royal Society." *Science* 84, no. 2190 (1936): 539-46. http://www.jstor.org/stable/1663153.

Davison, Charles. *Great Earthquakes.* London: Thomas Murby & Co., 1936.

_____. "Richard Dixon Oldham." *Obituary Notices of Fellows of the Royal Society* 2, no. 5 (Dec. 1936): 111-113. http://www.jstor.org/stable/769131.

_____. *The Founders of Seismology.* Cambridge: Cambridge University Press, 1927.

Dutton, Clarence Edward. *Earthquakes in the Light of the New Seismology.* New York: G. P. Putnam's Sons, 1904. https://hdl.handle.net/2027/nyp.33433090751540.

"Earthquake and Elephants." *The Amrita Bazar Patrika*. (Calcutta), July 26, 1897. http://infoweb.newsbank.com.ezproxy.lib.ou.edu/iwsearch/we/HistArchive/?p_product=WHNPX&p_theme=ahnp&p_nbid=K5EJ51WMMTUyNDAxNTAyOC4zMzcyNDY6MToxMjoxMjkuMTUuMTQuNDU&p_docref=v2:131DE1D267345E49@WHNPX-1467343D1F5652D8@2414132-14668E50EE36BFE0@4.

"Earthquakes and the New Seismology." *The Living Age.* (Boston), June 24, 1905. https://search.proquest.com/docview/90219783?accountid=12964%0A.

Gait, Edward Albert. *A History of Assam.* Calcutta: Thacker, Spink & Co., 1906.

https://hdl.handle.net/2027/nyp.3343308 Memoirs of 18832438841.

Geological Survey of India. *Memoirs of the Geological Survey of India* vol. 19. Calcutta: Office of the Geological Survey, 1883. https://hdl.handle.net/2027/mdp.39015035542151.

_____. *Memoirs of the Geological Survey of India* vol. 29. Calcutta: Office of the Geological Survey, 1899.

_____. *Memoirs of the Geological Survey of India* vol. 38. Calcutta: Office of the Geological Survey, 1910.

Gilbert, G. K. "The New Seismology." *Science* 20, no. 520 (1904): 837-838. http://www.jstor.org/stable/1630325.

Herschel, John F. W., ed. *A Manual of Scientific Enquiry; Prepared for the Use of Officers in Her Majesty's Navy; and Travellers in General.* 2nd ed. London: John Murray, 1851. https://hdl.handle.net/2027/nyp.33433069064008.

Hixon, Hiram W. "Earthquakes in Light of the New Seismology." *Journal of the Franklin Institute* 168, no. 3 (1909): 227-234. https://www.sciencedirect.com/science/article/pii/S0016003209901430?via%3Dihub.

"India's Severe Earthquake." *New York Times.* (New York), June 15, 1897. https://search.proquest.com/docview/95453073/615EF02E4FF94E14PQ/36?accountid=12964.

Kikuchi, "An Earthquake Investigation Committee." *Nature* 46, no. 1192 (1892): 418. http://www.nature.com.ezproxy.lib.ou.edu/articles/046418a0.pdf.

Lewes, George Henry. *Comte's philosophy of the sciences: Being an Exposition of the Principles of the Cours de Philosophie Positive of August Comte.* London: Bell & Daldy, 1871. https://hdl.handle.net/2027/hvd.hnu6u8.

Mallet, Robert. *Great Neapolitan Earthquake of 1857. The First Principles of Observational Seismology as Developed in the Report to the Royal Society of London of the Expedition Made by Command of the Society into the Interior of the Kingdom of Napes, to Investigate the Circumstances of the Great Earthquake of December 1857,* volumes 1&2. London: Chapman and Hall, 1862. https://hdl.handle.net/2027/mdp.39015064473799.

Middlemiss, Charles Stewart. "Obituary Notice of Richard Dixon Oldham." *The Quarterly Journal of the Geological Society of London* 93 (1937): ciii-cvi. http://jgs.lyellcollection.org/content/jgsleg/93/1-4/i.full.pdf.

Milne, John. “The New Seismology.” *Nature* 91, no. 2269 (1913): 190-191. https://www.nature.com/articles/091190b0.

_____. *Seismology with Fifty-Two Figures.* 2nd ed. London: Kegan Paul, Trench, Trübner, & Co., 1908.

Oldham, Richard Dixon. “A New Geography.” *The Geographical Journal* 34, no. 2 (1909): 156-66. http://www.jstor.org/stable/1777819.

_____. “Recent Earthquakes.” *The Geographical Journal* 33, no. 3 (1909): 294-297. http://www.jstor.org/stable/1776903.

_____. “Seismographs and Seismograms.” *Nature* 77, no. 1994 (Jan 2018): 246-247. https://rdcu.be/LP4y.

_____. “The Constitution of the Interior of the Earth, as Revealed by Earthquakes.” *Quarterly Journal of the Geological Society* 62 (1906): 456-475. https://hdl.handle.net/2027/njp.32101083531671.

_____. “The Constitution of the Interior of the Earth, as revealed by Earthquakes: (Second Communication). Some New Light on the Origin of the Oceans.” *Quarterly Journal for the Geological Society* 63 (1907): 344-350. https://hdl.handle.net/2027/njp.32101083531630.

_____. “The Italian Earthquake of December 28, 1908.” *The Geographical Journal* 33, no. 2 (Feb 1909): 185-188. http://www.jstor.org/stable/1777372.

Reid, Harry Fielding. "The Meeting of the International Seismological Association." *Science* 27, no. 680 (1908): 74-76. http://www.jstor.org/stable/1632168.

_____. “The Problems of Seismology.” *Geophysics* 6 (1920): 555-561. http://www.pnas.org/content/pnas/6/10/555.full.pdf.

Report on the Administration of Assam for the Year 1897-98. Shillong: Printed at the Assam Secretariat Printing Office, 1899. https://play.google.com/books/reader?id=yJM-AQAAMAAJ&printsec=frontcover&output=reader&hl=en&pg=GBS.PP2

Roy, Jagadananda. “Wall-Rocking Phenomonon at Krishnagar.” *The Amrita Bazar Patrika.* (Calcutta) July 24, 1897. http://infoweb.newsbank.com.ezproxy.lib.ou.edu/iw-search/we/HistArchive/?p_product=WHNPX&p_theme=ahnp&p_nbid=K5EJ51WMMTUyNDAxNTAyOC4zMzcyNDY6MToxMjoxMjkuMTUuM

TQuNDU&p_action=doc&p_queryname=2&d_viewref=browse&d_article_id=&d_db=&d_pbi=131DE1D267345E49&d_issue_id=1467343BE7A7B3F0.

Statement Exhibiting the Moral and Material Progress and Condition of India during the Year 1901-1902, and the Nine Preceding Years. London: Eyre and Spottiswoode, 1903. https://books.google.com/books?id=PfU2AQAAMAAJ&printsec=frontcover#v=onepage&q&f=false.

The Earthquake in Bengal and Assam: Reprinted from the "Englishman." Calcutta: Englishman Press, 1897. http://hdl.handle.net/2027/umn.31951p001680581.

"The Earthquakes in India." *The Manchester Guardian.* (Manchester, UK) August 11, 1897. https://search.proquest.com/docview/483434577/615EF02E4FF94E14PQ/37?accountid=12964.

"The Indian Shakes. Appalling Ruin in the Province of Assam – Renewals." *Los Angeles Times.* (Los Angeles), June 19, 1897. https://search.proquest.com/docview/163833536/615EF02E4FF94E14PQ/33?accountid=12964.

"The International Association of Seismology." *Nature* 77, no. 1986 (1907): 60-61. https://rdcu.be/LQb0.

Secondary

Agnew, Duncan Carr. "History of Seismology." In *International Handbook of Earthquake & Engineering Seismology, Part A.* London: Academic Press, 2002. https://igppweb.ucsd.edu/~agnew/Pubs/agnew.a66.pdf.

Ambraseys, Nicolas and Roger Bilham. "Reevaluated Intensities for the Great Assam Earthquake of 12 June 1897, Shillong, India." *Bulletin of the Seismological Society of America* 93, no. 2 (2003): 655-673. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.821.838&rep=rep1&type=pdf.

Behal, Rana P. "Power Structure, Discipline, and Labour in Assam Tea Plantations under Colonial Rule." *International Review of Social History* 51, supplement 14. (2006): 143-172.

Bijker, Wiebe E. *On Bicycles, Bakelites, and Bulbs: Towards a Theory of Sociotechnical Change.* Cambridge: The MIT Press, 1997.

C. D. P. “The Rossi-forel Scale of Earthquake Intensity.” *Publications of the Astronomical Society of the Pacific* 7, no. 41 (April 1895): 123-125. http://www.jstor.org/stable/40670542.

Clancey, Gregory. *Earthquake Nation: The Cultural Politics of Japanese Seismicity, 1868-1930.* Berkeley: University of California Press, 2006.

Coen, Deborah R. *The Earthquake Observers: Disaster Science from Lisbon to Richter*. Chicago: The University of Chicago Press, 2013.

Crawford, Elisabeth. *Nationalism and Internationalism in Science, 1880-1939: Four Studies of the Nobel Population.* Cambridge: Cambridge University Press, 1992.

Goswami, Priyam. *Assam in the Nineteenth Century: Industrialization and Colonial Penetration.* Guwahati, Delhi: Spectrum Publications, 1999.

Greene, Mott T. *Alfred Wegener: Science, Exploration, and the Theory of Continental Drift*. Baltimore: Johns Hopkins University Press, 2015.

_____. *Geology in the Nineteenth Century: Changing Views of a Changing World*. Ithaca: Cornell University Press, 1982.

Grout, Andrew. “Geology and India, 1770-1851. A Study in the Methods and Motivations of a Colonial Science.” Doctoral dissertation, London University, 1995.

_____. "Oldham, Richard Dixon (1858–1936), geologist and seismologist." *Oxford Dictionary of National Biography.* 29 Mar. 2018. http://www.oxforddnb.com.ezproxy.lib.ou.edu/view/10.1093/ref:odnb/9780198614128.0 01.0001/odnb- 9780198614128-e-37820.

Hazarika, Sanjoy. “The Assam Type House.” *The Indian Express*, April 30, 2015. http://indianexpress.com/article/opinion/columns/the-assam-type-house/.

"Jagadananda Roy (1869-1933)." Visva-Bharati: A Central University and an Institution of National Importance, accessed February 20, 2018, http://www.visvabharati.ac.in/JagadanandaRoy.html.

Krishna, Jai. “Development of Earthquake Engineering Studies in India.” *Journal of the Indian Geophysical Union* 7, no. 3 (October, 1970): 59.

Krishnaswamy, V. S. “Foreward.” In *Memoirs of the Geological Survey of India* vol. 29. 1981 Reprint. Calcutta: Office of the Geological Survey, 1899.

Kumar, Deepak. “Economic Compulsions and the Geological Survey of India.”

Indian Journal of History of Science 17, no. 2 (1982): 289-300.

_____. *Science and the Raj, 1857-1905*. Delhi: Oxford University Press, 1995.

Maclean, Kama. "The Art of Panicking Quietly: British Expatriate Responses to 'Terrorist Outrages' in India, 1912-33." In *Anxieties, Fear and Panic in Colonial Settings: Empires on the Verge of a Nervous Breakdown,* ed. Harald Fischer-Tiné. Cham, Switzerland: Palgrave Macmillan, 2016.

Musson, Roger M W, Grünthal, Gottfried, Stucchi, Max. "The comparison of macroseismic intensity scales." *Journal of Seismology* 14, no. 2 (2010): 413-428.

"Oldham, Richard Dixon." In *Complete Dictionary of Scientific Biography*, 203. Vol. 10. Detroit: Charles Scribner's Sons, 2008. *Gale Virtual Reference Library*. http://link.galegroup.com.ezproxy.lib.ou.edu/apps/doc/CX2830903221/GVRL?u=norm94900&sid=GVRL&xid=168af9d2.

Prakash, Gyan. *Another Reason: Science and the Imaginations of Modern India*. Princeton: Princeton University Press, 1999.

Raj, Kapil. *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900.* New York: Palgrave Macmillan, 2007.

Sudmeier-Rieux, K., Jaboyedoff, M., Breguet, A., & Dubois, J. "The 2005 Pakistan earthquake revisited: Methods for integrated landslide assessment." *Mountain Researchand Development,* 31, no. 2 (2011): 112-121.

"The History of Seismology." Preceden. Accessed April 19, 2018. https://www.preceden.com/timelines/40019-the-history-of-seismology.

Tilley, Helen. *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950.* Chicago: University of Chicago Press, 2011.

Tolman, Aja. "Geologists and the British Raj, 1870-1910." Master's thesis, Utah State University, 2016.

Valenčius, Conevery Bolton. *The Lost History of the New Madrid Earthquakes*. Chicago: University of Chicago Press, 2015.

Walker, Charles F. *Shaky Colonialism: The 1746 Earthquake-Tsunami in Lima, Peru, and Its Long Aftermath*. Durham, NC: Duke University Press, 2008.

Westermann, Andrea. "Disciplining the Earth: Earthquake Observation in Switzerland and Germany at the Turn of the Nineteenth Century." *Environment and History* 17, no. 1 (Feb 2011): 53-77.